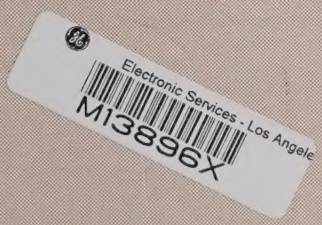
DIRECTIONS

177584 *Issue* 6

6430 AND 6460 SERIES

ELECTROMAX® III CONTROLLERS

General Electric Company



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LEEDS & NORTHRUP

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SPECIFICATIONS

INPUT

Low Level

Thermocouple or other emf source.

High Level

Transmitters with high output voltage (0 to 10 V dc) or current.

INPUT RANGES

See Table I.

SET POINT

Control Sensitivity: with automatic reset and minimum proportional band setting, 0.05% of deviation output. Example: For a ±50 degree meter calibration, the output will full stroke with a 0.025 degree error signal. Under these conditions, less than ±0.1 μV error signal will cause a measurable change of the controller output.

Digital Setter

Accuracy: ±0.5% of input span at calibration points (see Table IV). Accuracy at other points varies since the thermocouple emf versus temperature is non-linear. Failsafe circuit causes a slight error in microvolts that is approximately equal to 0.2 μA times source resistance in ohms.

Linearity of Set-Point Potentiometer: 0.25%.

Repeatability: 0.05% of span with 1000 count counter.
0.03% of span with 2000/5000/10,000 count counter.

Indication: Multiturn set-point potentiometer is geared to a four-digit counter for direct readout in degrees or millivolts.

Analog Setter

Accuracy: ±1% of input span at calibrated points. (See Table IV.)

Linearity of Set-Point Potentiometer: 1%.

Resolution: 0.5% of span.

Indication: Single-turn, set-point potentiometer is direct-coupled to a drum-type scale, calibrated in degrees or millivolts.

DEVIATION METER

Zero-center, 2 mA meter with an accuracy of ±3%. Scale is linearly calibrated to represent deviation from set point of ±50 degrees for the temperature ranges or ±5% of the millivoltage ranges for digital setter, and ±10% of the millivoltage ranges for the analog setter.

DEVIATION AMPLIFIER

Open loop gain is approximately 5×10^6.

FAILSAFE FEATURES

If an ac power failure occurs, the controller output becomes zero, or output relays become de-energized, depending upon the type of controller.

Input Circuit Failsafe

For upscale failsafe, when R9 is in jack US, if the thermocouple circuit opens, the controller output responds as if the input were above set point.

For downscale failsafe, when R9 is in jack DS, if the thermocouple circuit opens, the controller output responds as if the input were below set point.

When failsafe is not used, R9 is in jack NC.

CONTROLLER OUTPUT

The controller output depends upon the type of driver card specified by the catalog number.

6430 Voltage Output (No Driver)—±10 V dc into a 10 kΩ load (minimum) (1 mA max).
6431 P.A.T. Output—Two triac switches for applying 120 V/1 A ac max to drive unit motors.
6432 C.A.T. Output (hard)—0-5 mA max into 2 kΩ load, or 0-20 mA max into 500Ω load.
6433 D.A.T. Output**—N.O. contact* rated at 10 W max 0.5 A max - 120 V ac or 200 V dc max.
6434 P.E.T. Output—1 kW load at 120 V ac (isolated from input).
6435 C.A.T. Output (Soft)—0-5 mA max into 2 kΩ, or 0-20 mA max into 500Ω load.
6437 ON-OFF Output**—N.O. contact* rated at 10 W max 0.5 A max - 120 V ac or 200 V dc max.
6438 Overheat Alarm Output—1 N.O. and 1 N.C. contacts* rated at 3A-120V ac max.

* Contacts isolated from signal common. Do not exceed any of these maximums (P=EI).
**With J805 suffix - Isolated triac output (ac only) for 100 W max, 1 A max. & 120 V ac max.
or with H21 suffix - Isolated triac output (ac only) for 1 kW max. at 120 V ac.

SPECIFICATIONS

AUTO-MANUAL OPERATION (OPTION)
Manual station (pushbuttons on front panel) and automatic transfer relay, when supplied with proportioning controllers provide bumpless, manual-to-automatic transfer without balancing. However, with the exception of the soft C.A.T. (6435) and P.A.T. (6431) controllers, bumpless automatic-to-manual transfer requires prior balancing.

DEVIATION ALARM (OPTION)
Input Signal: ±5 V dc (equivalent to ±50°C or F). Trip points can be adjusted.
High and Low Alarm Output: 1 isolated contact closure or closure to +30 V dc (25 mA max) supply. See Section 7E(8).
Two deviation alarm circuits provide two independent high and low alarm contacts.

CONTROL ADJUSTMENTS (OPTION)
Proportional Band: 0-200° for digital setter with 0 to ±50° meter calibration, or 0-40% of full-scale for analog setter.

Wide Proportional Band: Ten times Proportional Band.

Reset: 0.05-50 repeats per minute.

Rate: 0-5 minutes.

Inverse Rate: 0-30 seconds.

Approach: 0-100 (not calibrated).

INPUT/OUTPUT CIRCUIT (OPTION)
I/O PC card (444862) accuracy: 2%.
I/O meter: 0-center, 500μA meter and PC card provide for full-scale input or output indication (0-100 scale).

STABILITY
±0.1% of span for line voltage variations between 107 and 127, 50/60 Hz.
±0.01% of 30 mV span per degree Fahrenheit (3 μV/°F max).

WARMUP
Drift: 0.5% of 10 mV input range.

Time: 5 minutes (15 minutes for thermocouple inputs).

INTERFERENCE REJECTION
Transverse (60 Hz): 42 dB (126:1).
Common Mode (60 Hz): 120 dB (1,000,000:1).

MAXIMUM COMMON MODE VOLTAGE
120 V, 50/60 Hz, or 150 V dc.

POWER REQUIREMENTS
107 to 127 V, 50/60 Hz, 7 VA.

AMBIENT TEMPERATURE
40 to 120°F. (32 to 140°F with specifications derated by a factor of 2.)

HUMIDITY
90% R.H. max at 104°F. (95% R.H. with specifications derated by a factor of 2.)

CASE MOUNTING
In steel panel with 1/8" min thickness. Requires panel cutout 3" wide and 6-1/2" high.

CASE DIMENSIONS
3-1/2" (89 mm) wide, 6-5/8" (168 mm) high, and 11" (280 mm) deep.

WEIGHT
Approximately 7 pounds (3.2kg) (case and controller).

6430 AND 6460 SERIES
ELECTROMAX III CONTROLLERS

PART I GENERAL INFORMATION

1. INTRODUCTION

The 6430 Series Electromax Controller* is a low-cost, high-precision, solid-state instrument designed for a variety of controller applications involving both high and low-level input signals. For maximum utility, the controller is provided with a dual input system. The low-level input accepts dc signals derived from a thermocouple, Thermohm® detector circuit, or other millivoltage source below 100 mV dc with an impedance of 1000 ohms or less. The high-level input accepts dc signals derived from a pressure or differential pressure transmitter, level transmitter, tachometer or other high-level source with an output range up to 10 V dc.

The dual input system of the Electromax controller increases the scope of applications in which the controller can be used. For example, the high-level input can function as an injection point for a remotely-generated reference potential against which the low-level signal can be compared, or the low-level signal can be used as a reference for the high-level signal. This makes possible various master-slave control arrangements, as well as a means by which cascading can be performed. The dual input system can also be used in maintaining the ratio of one variable to another, or for biasing the set point reference such as is required in a non-interacting control system.

The controller compares the input signal with the set-point voltage to produce the desired control action. The type of controller output is determined by the driver card used, which modifies the basic controller output for a current-adjusting-type (C. A. T.), position-adjusting-type (P. A. T.) or duration-adjusting-type (D. A. T.) control system. The controller is also available with a zero-phase fired, 1-kW triac circuit or with an ON-OFF driver for low-power applications.

Internal manual stations are available for automatic and manual modes of operation with the 6430 Series Electromax Controllers for all except the ON-OFF and Overheat types.

Fig. 1 shows the front panel of two Electromax III controllers with an analog and digital set-point setter. The controller is also available without a setter for remote set point.

*Reference to 6430 Series also pertains to 6460 Series in this book. The 6460 is a 6430 in the same case with a recorder or Trendtrak.

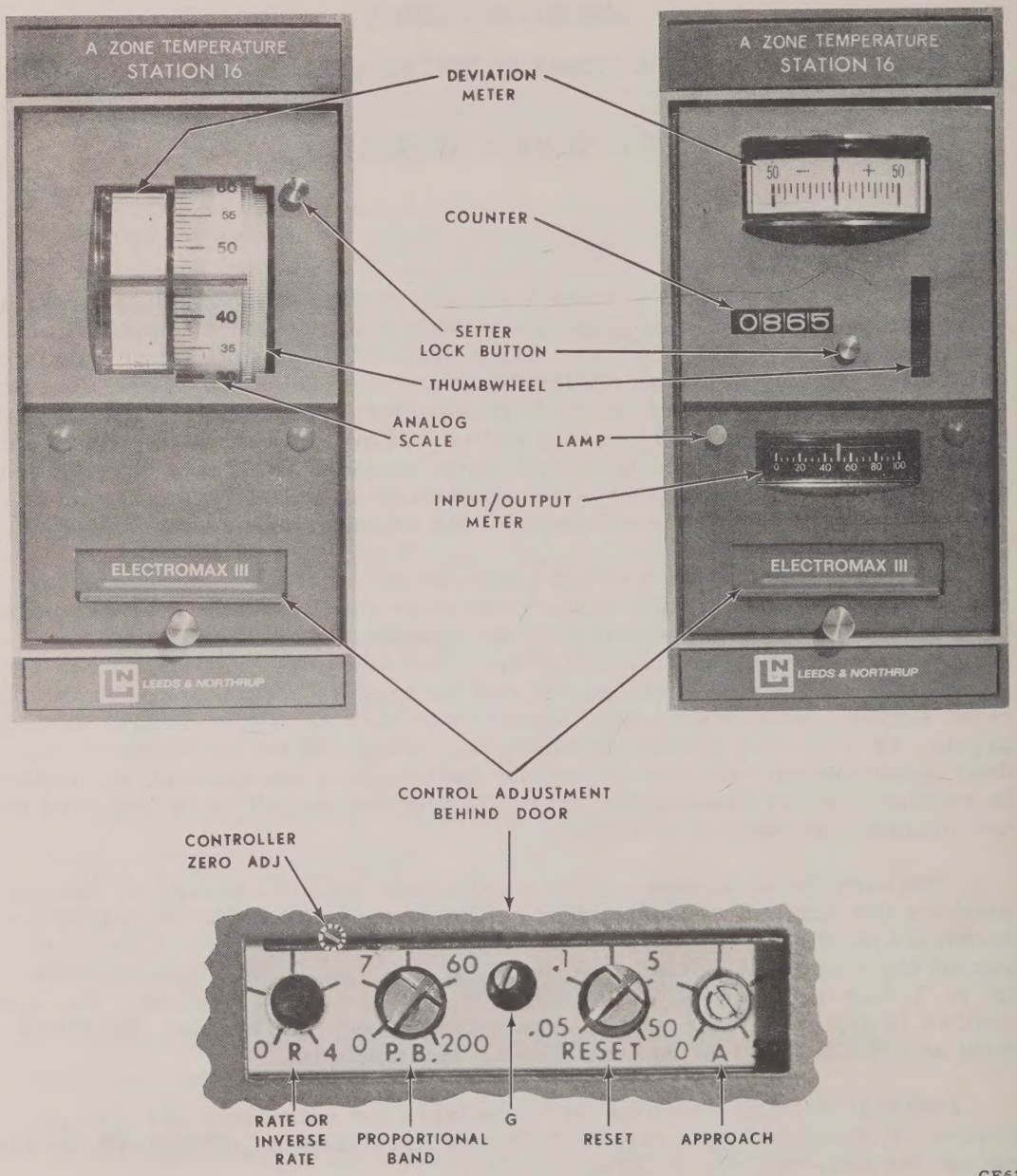

Fig. 1–Electromax III controllers with digital and analog setters. Insert shows control adjustments behind door at bottom of front panel. The function of adjustment G (R62) is determined by the type of driver used; P.A.T. – Dead band adj., C.A.T. – Max. Current adj., and D.A.T. – Impulse Rate adj.

DO NOT DISTURB CONTROLLER ZERO ADJ. EXCEPT WHEN FOLLOWING THE CALIBRATION PROCEDURE IN SECTION 21K.

2. DESCRIPTION

2A. General Information

The catalog number of the controller identifies the type of controller and its various features. The catalog number code of the Electromax III is shown below.

CATALOG NUMBERING CODE OF ELECTROMAX III

	A	B	C	DEF	G	H	J
CATALOG NUMBER	643☐-	☐-	☐☐☐-	☐☐☐-	☐-	☐☐-	☐☐☐- ☐☐☐

SUFFIX A - Type of Controller (Output Driver)

	Output
Basic Controller - ±10 V dc at 1 mA max.	-0
P.A.T. Controller - Dual 100 W Triacs	-1
C.A.T. (Hard) Controller - 0-5/0-20 mA dc	-2
D.A.T. Controller - 10 W Reed Relay Contact	-3
P.E.T. Controller - 50 mA Trigger (Zero Phase)	-4
C.A.T. (Soft) Controller - 0-5/0-20 mA dc	-5
ON-OFF Controller - 10 W Reed Relay Contact	-7
Overheat/Underheat Alarm - 3 A/120 V Relay Contact	-8

SUFFIX B - Set Point Setter

	1	2	3	4	5	6	7	8
Blank Front Panel*	x	x						
Deviation Meter		x	x	x	x	x	x	x
Analog Setter			x	x				
Remote/Local Switch			x		x		x	
Digital Setter					x	x		
Precision Dig. Setter							x	x

*For use with remote setter.

SUFFIX C - Input Range
See Table I

SUFFIX D - Control Functions

	0	1*	2	3	4	5	6	7	8
Error Detection only	x								
Proportional Band (0-200°)		x	x	x	x	x			
Wide Proportional Band (0-2000°)							x	x	x
Reset			x	x	x	x	x	x	x
Rate				x		x			x
Inverse Rate								x	
Approach					x	x			

*Suffix D1 with 6437 (ON-OFF) controller provides deadband adjustment.

SUFFIX E - Alarm & Signal Options

	0	1	2	3	4	5	6	7	8	9
None	x									
1 Deviation Alarm Contact (& Signal Light)		x			x				x	
2 Deviation Alarm Contact			x							
1 Input Alarm				x	x		x			
2 Input Alarm						x				
Output Signal Prop. to Inp.							x	x	x	
Special Alarm and Signal Options										x

SUFFIX F - Control Features

	0	1	2	3	4	5	6	7
Controller Action:								
Forward Control Action	x		x		x		x	
Reverse Control Action		x		x		x		x
ATR Relay			x	x			x	x
Set Point Bias Connection					x	x	x	x
Alarm Action:								
Overheat	x			x		x		
Underheat		x	x		x			
Automatic Alarm Reset			x	x				
Power-Failure Trip					x	x		

SUFFIX G - Front Panel Options

	0	1	2	3	4	5
None	x					
Input Meter		x				
Output Meter			x			
Manual Station (Hard)				x		
Manual Station (Soft)					x	
Manual Station - P.A.T.						x

SUFFIX H - Case Features

	00	01	02	10	20	21	22
No case, no terminal board	x	x	x				
Terminal Board				x	x	x	x
Case					x	x	x
1 kW AC Output ON-OFF/D.A.T		x				x	
1 kW AC Output P.E.T.			x				x

SUFFIX J - Additional Options

Tags	
Metalcal	205
Linen	206
Aluminum	207
Stainless Steel	208
Controller in Multipack Case	210
Engraved Nameplate	300
Case Delivered Separately	400
Deviation Signal Wired to Terminal Boards	520

SUFFIX J - Additional Options (Cont'd)	
Alarm(s) Wired to Provide +30 V dc on Terminals when in Alarm Condition	522
Black Finish	600
Installation Wiring Diagram	701
Future Manual Station	800
0-20 mA Output on C. A. T.	802
Polarity Reverse Switch	803
Triac Booster Wired to Alarm	804
ON-OFF/D. A. T. - 1A ac Output	805
0-40 mA, 10-50 mA Shunts	810
0-16 mA, 4-20 mA Shunts	811
0-4 mA, 1-5 mA Shunts	812
0-40 mA, 10-50 mA Ratio Shunts	813
0-16 mA, 4-20 mA Ratio Shunts	814
0-4 mA, 1-5 mA Ratio Shunts	815
Deviation Alarm - Below set point only	836
Deviation Alarm - Above set point only	837
C. A. T. Output - 1 to 5 mA dc	840
C. A. T. Output - 4 to 20 mA dc	841
Calibrated as Secondary Controller in Cascade Loop	850
Switch for Tuning Ratio Controller from Stable Source	860
Dual Control Option	870
pH Ranges (4150-3)	880
D. A. T. Output with 0.5 to 5 IPM	891
D. A. T. Output with 2 to 20 IPM	892

When a 10967 Multi-Pack Case has been ordered for several Electromax controllers, each Electromax controller has been ordered separately, its Suffix J (on the nameplate) must be 210 and 508, and Suffix H must be either; 00, 01 or 02. The case and terminal boards are supplied as part of the multi-pack case. The multi-pack case is shipped with the controllers and all the case components in place (except where future controllers are specified).

The catalog numbering code of the Multi-Pack Case is as follows:

CATALOG NUMBERING CODE OF MULTI-PACK CASE

CATALOG NUMBER - 10967 -

Number of Positions (1)

Three	- 3
Four	- 4
Five	- 5
Special	- 9

Controller Positions (2)

Electromax III	- No Triac - 1
Electromax III	- With Triac - 2
Electromax IV	- No Triac - 3
Electromax IV	- With Triac - 4

Controller Positions (2) (Cont'd)

Future Electromax III - No Triac	- 5
Future Electromax III - With Triac	- 6
Future Electromax IV - No Triac	- 7
Future Electromax IV - With Triac	- 8
Special	- 9

Options (3)

Engraved Nameplate	- 300
Case Delivered Separately	- 400
Black Finish	- 600

Suffix 2 denotes the type of case supplied for the controller in each position A to E, left to right as viewed from the front. When a position is reserved for future use, a blank front panel is supplied.

EXAMPLE: Cat. 10967-4-1247-300

Engrave "Zone No. 1" in position A
Engrave "Zone No. 2" in position B
Engrave "Zone No. 3" in position C
Do not engrave position D.

This is a four-position Multi-Pack case with an Electromax III without triac, an Electromax III with triac, and Electromax IV with triac and a future Electromax IV without triac in positions A, B, C, and D, respectively. The 300 option calls for the engraving as shown.

The Electromax III controller compares the input voltage with an internal reference voltage to provide a ±10 V dc output which is a function of the difference between the two voltages. This is converted by a driver card to obtain one of the input-output relationships shown in Fig. 2.

The reference voltage is established by a high-level, digital or analog setter in the controller or by a remote setter. A deviation meter, which is normally provided on all units, indicates the deviation of the input from set point in degrees or percent of full-scale input. Failsafe and reference junction temperature compensation circuits are provided for thermocouple applications. The controller consists of a deviation amplifier, control amplifier, driver, and ±15 and ±30 V dc power supplies.

Various combinations of additional features are provided with the basic controller when specified by catalog number. An input meter indicates the input signal in percent of full range. The control features -- reset, rate and approach -- modify the action of the control amplifier before it is applied to the output driver. An optional output meter indicates the controller output (except on ON-OFF and overheat) in percent of full-scale output. A deviation alarm indicates when the input signal is off set point by preset amount. An ATR relay provides bumpless transfer between

manual and automatic modes. A manual station pushbutton switch provides automatic to manual mode transfer and manual adjustment of the final control element. Input alarm(s) indicate when the process is beyond the preset value.

2B. Basic Controller - 6430

The basic (V.A.T.) controller (without a driver card) provides a ±10 V dc output (10 kΩ min.). The output is reverse acting; i.e., positive with input above set point.

2C. Position-Adjusting-Type Controller - 6431

The P.A.T. controller provides solid-state switching through a pair of 1 A triacs. This applies the line voltage to one of the windings of a bidirectional motor to change its shaft position by rotating the shaft in one direction or the other in response to a deviation of the input signal from set point. An amber lamp indicates that the input signal is at set point or above when lit. Controller input is isolated from output. The 6431 controller is designed to directly operate 10218 or 10260 Series Drive Mechanisms and 10973 Series Motor-To-Pneumatic Converters with 1000-ohm feedback slidewires.

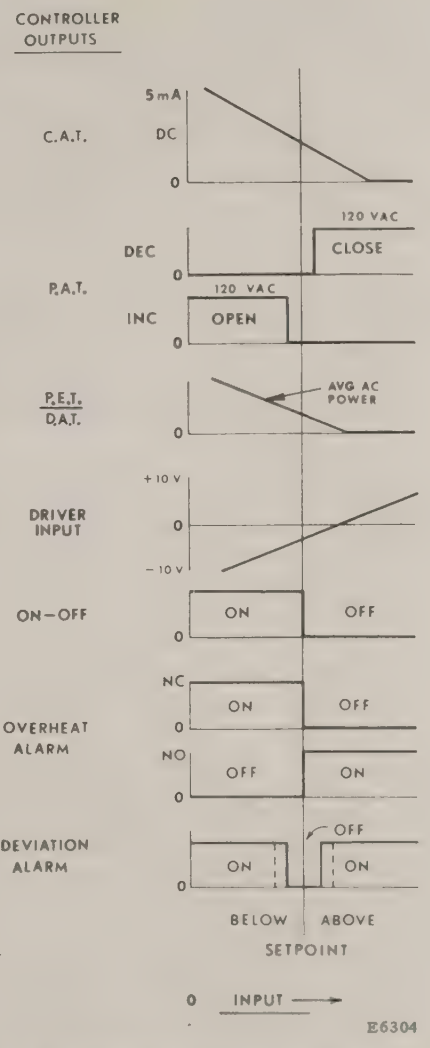

Fig. 2–Controller outputs vs input for standard control action (assuming steady-state conditions).

When the P.A.T. manual station (G5) is specified, automatic-manual transfer and manual adjustment can be obtained by means of the L, A, R pushbuttons. An M pushbutton when depressed changes the function of the deviation meter to a position meter for the drive unit. Bumpless manual-to-automatic transfer is obtained when the ATR relay (F2, 3, 6 or F7) is specified (bumpless/transfer from automatic to manual is inherent in the P.A.T. controller).

2D. Current-Adjusting-Type (Hard) Controller - 6432

The C.A.T. (Hard) controller provides a 0-5 mA dc* (maximum load of 2000 ohms) output whose magnitude varies with deviation of input signal

*Also 1 to 5 mA output. Outputs of 0 to 20 mA or 4 to 20 mA into 2000-ohm max. Loads are possible by changing a jumper position.

from set point, for electric heating with SCR power packages, saturable core reactors, magnetic amplifiers, or for operation of an electro-pneumatic converter. A maximum current adjustment limits the output current within its range.

When the hard manual station (G3) is specified, the controller output can be manually set with excellent long-time stability at any point within the output range, and provision is made for transferring between the automatic and manual modes, by pressing the A button. An M button when depressed changes the function of the deviation meter to an output meter. An ATR relay (F2, 3, 6 or 7) must be specified to provide bumpless transfer from manual to automatic modes. However, the transfer from automatic to manual is not bumpless.

2E. Duration-Adjusting-Type Controller - 6433

The D.A.T. controller operates an isolated contact rated at 10 watts maximum at On/Off times proportional to the deviation of input signal from set point**. An amber lamp lights when the contact is closed. When the triac assembly (H21) is specified, the output capability is increased to 1 kW (ac only).

Automatic-manual transfer and manual adjustment of output can be obtained when the hard manual station (G3) and the ATR relay (F2, 3, 6 or F7) are specified (Sec. 2D).

2F. Power Element Trigger Controller - 6434

The P.E.T. controller provides output pulses (50μsec.±20%) synchronized with the line voltage for zero voltage firing of a power element (triac assembly). The pulse has an open-circuit voltage of 5 V dc max. and a short-circuit current of 100 mA dc max. With the output pulses applied to a power element, the line voltage is switched on and off in such a way that the load power is proportional to the deviation of the input signal from set point. When the triac assembly (H22) is specified, the output capability is 1 kW at 120 V ac, with input/output isolation.

Automatic-manual transfer and manual adjustment of output can be obtained when the hard manual station (G3) and the ATR relay (F2, 3, 6 or F7) are specified (Section 2D).

2G. Current-Adjusting-Type (Soft) Controller - 6435

The C.A.T. (Soft) controller provides a 0-5 mA dc* (maximum load of 2000 ohms) output, whose magnitude varies with deviation of input signal from set point. The controller is used in electric heating with SCR power packages, saturable core reactors, magnetic amplifiers, or for operation of an electro-pneumatic converter. A maximum current adjustment limits the output current within the range.

*An output of 0-20 mA dc into a 500-ohm (max) load can be obtained by changing a jumper position.

**When suffix J805 is specified, the output capability is increased to 1A (ac only). Use an external relay for dc applications.

When the ATR relay (F2, 3, 6 or F7) is specified, the current output can be held at the latest current level by throwing an external switch which energizes the ATR and other relays in the controller.

When the soft manual station (G4) and ATR relay (F2, 3, 6 or F7) are specified, the output current can be manually adjusted by pressing one of the manual (L,R) buttons until the desired current level is reached. Transfer is bumpless in either direction.

2H. ON-OFF Controller - 6437

The ON-OFF controller operates an isolated contact which is closed when the input signal is below set point, and open above set point*. An amber lamp is lit when the contact is closed. When the triac assembly (H21) is specified, the output capability is increased to 1 kW, at 120 V (ac only).

2I. Overheat (or Underheat) Alarm - 6438

The alarm operates an alarm relay rated at 3 A, 120 V (NO and NC contacts). Depending upon how it is specified (F0-F5), the alarm operates as an overheat or underheat alarm, with or without automatic reset or power failure trip (See Section 9F). A red lamp indicates an alarm condition when lit.

2J. Control Functions

All controllers except the ON-OFF type and the overheat alarm are equipped with a proportional control circuit, but they may or may not have reset, rate and approach controls. When specified, these are adjustable by means of appropriate screwdriver-slot control, located behind the sliding door at the bottom of the front panel. See Fig. 1.

Proportional action changes the output of the controller and/or the final control element in proportion to a change in the controlled variable. The Proportional Band• scale is calibrated in degrees for digital setters, and in percent of full-scale input for analog setters. At a setting of 20°, for example, the final control element is full stroked by a 20° deviation from set point. It should be noted that the calibration markings are only approximate. Wide Proportional Band, which is also available, is ten times the Proportional Band range.

Reset action is an integrating action which corrects the output of the controller or final control element at a speed proportional to deviation of

*When suffix J805 is specified, the output capability is increased to 100W (ac only). Use an external relay for dc applications.

•The proportional gain, which is the reciprocal of proportional band, is expressed as the percent controller output change for a given controller input change. The term proportional band is used in this discussion since the Electromax III controller is calibrated that way.

controlled variable from set point. The Reset scale setting determines the ratio of integrating speed to deviation in terms of repeats per minute.* Reset action stops when the controlled variable is at the set point.

Inverse Rate (Lag) is an adjustable low-pass filter on the controller error signal. The RC time constant of the filter is adjustable from 0 to 30 seconds. By increasing the Lag setting, more fluctuations are filtered from the error signal but also a greater time lag is introduced in the signal change, so that it tends to degrade the control action. It should be used only where a fluctuating controlled variable signal produces excessive activity of the controller output or final control element.

Approach action is used in batch-type processes to minimize over-shoot during startup, where the controlled variable requires a considerable length of time to reach set point. Without approach action, the output may not move from its fully-on position until the controlled variable has reached set point. Consequently, the inertia of the process will cause the controlled variable to increase above set point and thus over-shoot. With approach action, the output of the controller and/or final control element is reduced before the controlled variable reaches set point. The higher the approach setting, the sooner the controller output is reduced. The controller has some inherent approach action due to the differential input nature of the control amplifier even without the approach option.

2K. Alarm and Output Signal Options

A deviation alarm has an adjustable range of 0 to 50° above and below set point for temperature ranges or 0 to 5% of other input ranges above and below set point when used in a controller with a digital setter. For an analog setter the adjustment is 0 to 10% of input range above and below set point. A single, output (N.O.) contact is provided for each deviation alarm specified. It is normally isolated, but will be connected to a +30 V dc, 25 mA supply if sufficient output terminals are not available. A red lamp on the front panel indicates the alarm condition. The sensitivity of the deviation alarm is about ±1 degree for digital setters and ±2 degrees for analog setters.

An input alarm has an adjustable range of 0 to 100% of input span with a nominally calibrated dial (0-50) corresponding to 0 to 100% of span. Its sensitivity is about ±1% of input range for digital setters and ±2% for analog setters. Its contact is N.O. below its setting.

An output-signal-proportional-to-input provides an adjustable 0 to 5 V dc into a 2000 max. external load, used primarily with remote high-level (M-line) recorder. Positive signal with forward-acting control, negative with reverse-acting control.

*One repeat per minute is defined as a change in the output of the controller over a period of one minute due to reset action that just equals the proportional step that a given error signal generates due to proportional action.

2L. Input and Output Meters

An input meter indicates the input signal in 0 to 100% of full range.

The output meter indicates one of the following:

Drive Unit Position	6431 P.A.T. Controller
Current Output - mA	6432 C.A.T. Controller (Hard) 6435 C.A.T. Controller (Soft)
% Output of Driver	6434 P.E.T. Controller
% ON Time	6433 D.A.T. Controller

2M. Option 870

The dual controller option provides a secondary ON-OFF control output which is energized when the output of the basic controller is below a preset level and the input is above setpoint and is de-energized when the input is below setpoint or when the output is above the preset level. This preset level is factory adjusted to a value corresponding to 20% of the output span of the basic controller and is field adjustable over a range of 0-100% of the output span of the basic controller. This secondary output is a triac rated at 1 kW, 120 V AC. An amber signal light indicating the status of the secondary controller will be supplied if the two indicating light positions have not been pre-empted by other control or alarm functions.

2N. Option 880

When the Electromax III controller is specified with option 880 and one of the 4150-series pH ranges listed in Table I, direct connection is possible to a 7773 or 7779 pH transmitter.

The 880 option provides two features on the Electromax controller required for direct operation with these pH transmitters. First, an input amplifier card is used on the controller terminal board to provide input signal inversion when reverse acting control is desired.

Secondly, an electrode "Standardizing Adjustment" potentiometer is provided on the control adjustment bracket, in the normal Approach slot. The STD pot is a front panel zero adjustment for the range allowing approximately ±1.5 pH adjustment for electrode standardization.

The 445259 input card is required only when reverse acting control is desired. On applications where a base (caustic) solution is being added to control pH, the Electromax should be specified as a forward acting controller. The 445259 card will still be supplied but with a W1 jumper in the FWD position.

The 445259 card is supplied with option 880 to permit the reverse action capability. In this case the W1 jumper is not used but W2 (in the REV position) applies. The reason for supplying the 445259 card is that

for a reverse action Electromax, one step (see section on reverse acting control) in setting up the controller requires that the input be reversed. However, the input connections on units used with the pH transmitter cannot be reversed since the controller is supplying power to the transmitter and therefore common cannot be reversed.

3. PHYSICAL DESCRIPTION

The controller assembly is a nominal 5" x 8" printed-circuit card with a control bracket fastened to the lower front end of the component side of the PC card. A front panel (3"W x 5"H), mounted on the bracket and PC card, holds the meters, lamps, and set-point assembly, when specified. The PC card is on the left when viewed from the front panel. As shown in Fig. 3, external connections to the controller PC card are made through a 14-contact card edge connector-terminal board combination at the back of the case. The connector also holds the controller in the case. See Appendix for assemblies and schematic diagrams.

The output of each controller, is modified for the specified output by a 16-contact driver PC card (P.A.T., C.A.T., etc.,) which is plugged into the controller PC card.

Various options are added, when specified, in the form of 1-1/2" x 3" PC cards which are screwed to studs (E and D) on the controller card. The studs also serve as connecting points between the option PC cards, the controller card and the front panel controls and indicators. Fig. 4 shows the location of these various features. Tables AI and AII in the Appendix list the various driver and option cards, triac assembly and manual station according to the catalog number.

3A. Front Panel Components

The components mounted on the front panel, when specified, are the set-point setter assembly, deviation meter, input or output meter, indicating lamps, and reset pushbutton (for overheat alarm). Control action adjustments (screwdriver slots) are located behind a door at the bottom of the panel.

Two set-point setters, analog and digital, are optionally available for use in the high-level set-point circuit. The analog setter consists of a single-turn potentiometer rotated by a three-inch thumbwheel with a drum-type calibrated scale 6-1/2 inches long. The thumbwheel is held in the desired position by a locking mechanism which can be released by a spring-loaded pushbutton on the front panel. (See Fig. 5(a).) The digital setter consists of a 10-turn potentiometer, a four-place counter and a thumbwheel to turn the potentiometer shaft and counter. Four gearing arrangements are provided which full stroke the potentiometer in 1000, 2000, 5000 or 10,000 counts. The locking mechanism is similar to that of the analog setter. (See Fig. 5(b).)

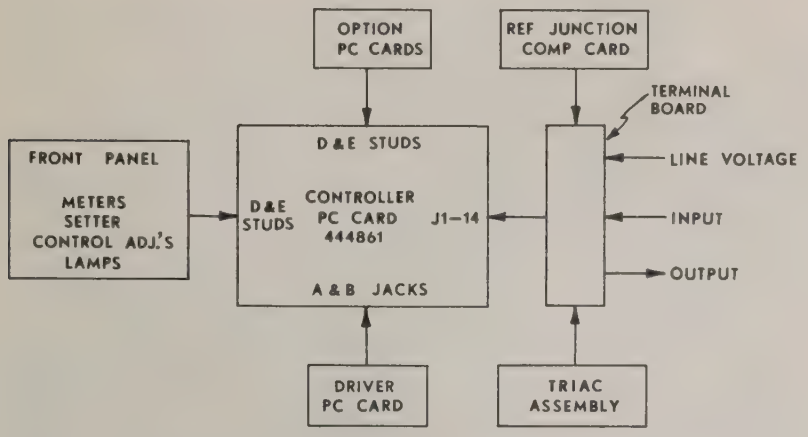

Fig. 3–Block diagram of 6430 Series Controller.

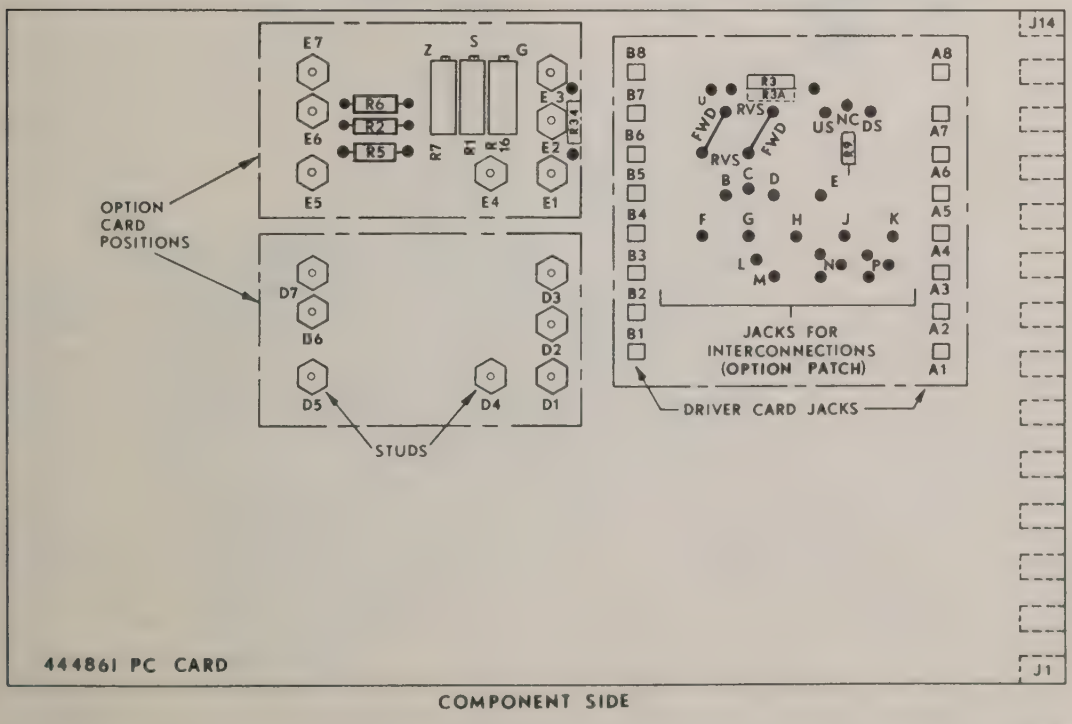

Fig. 4–Location of jacks and studs on 444861 PC card for option and driver cards, plug-in resistors (R2, R3, R5, R6, R34), jumpers, and front-panel component leads. Factory-set calibration adjustments Z, S and G are also shown.

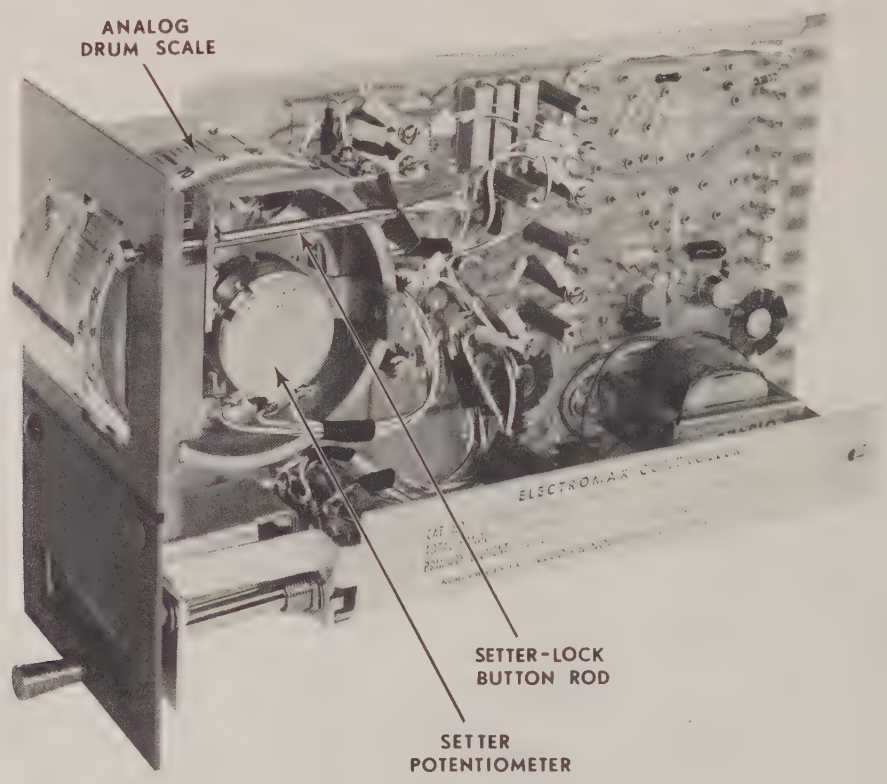

Fig. 5(a)–Controller with analog setter.

The Soft C.A.T. or P.A.T. manual station (G-4 or G-5) has four pushbuttons; L, M, A and R. When the automatic button (A) is depressed, the controller is latched in the automatic mode. When one of the manual buttons (L,R) is depressed, the automatic button is released and the controller is transferred to the manual mode.* As long as one of the manual buttons is depressed, the manual station output is applied to the final control element to effect a change in the process to raise or lower the value of the controlled variable. These three buttons (L,A,R) are interlocked so that only one of them can be in operation at a time. The front panel meter normally reads the deviation of the controlled variable from set point, in degrees F or C, or in percent of range. However, when the meter (M) button is depressed, the deviation meter indicates the output (50% output at zero center). (See Fig. 5(c), Position A)

The hard manual station (G-3) has two pushbuttons (M,A) and a knob. When the automatic (A) button is depressed, the controller is latched in the automatic mode. When the A button is released (by depressing again),

*On production units prior to April' 71, the A button has to be released separately by depressing again, since there is no interlock.

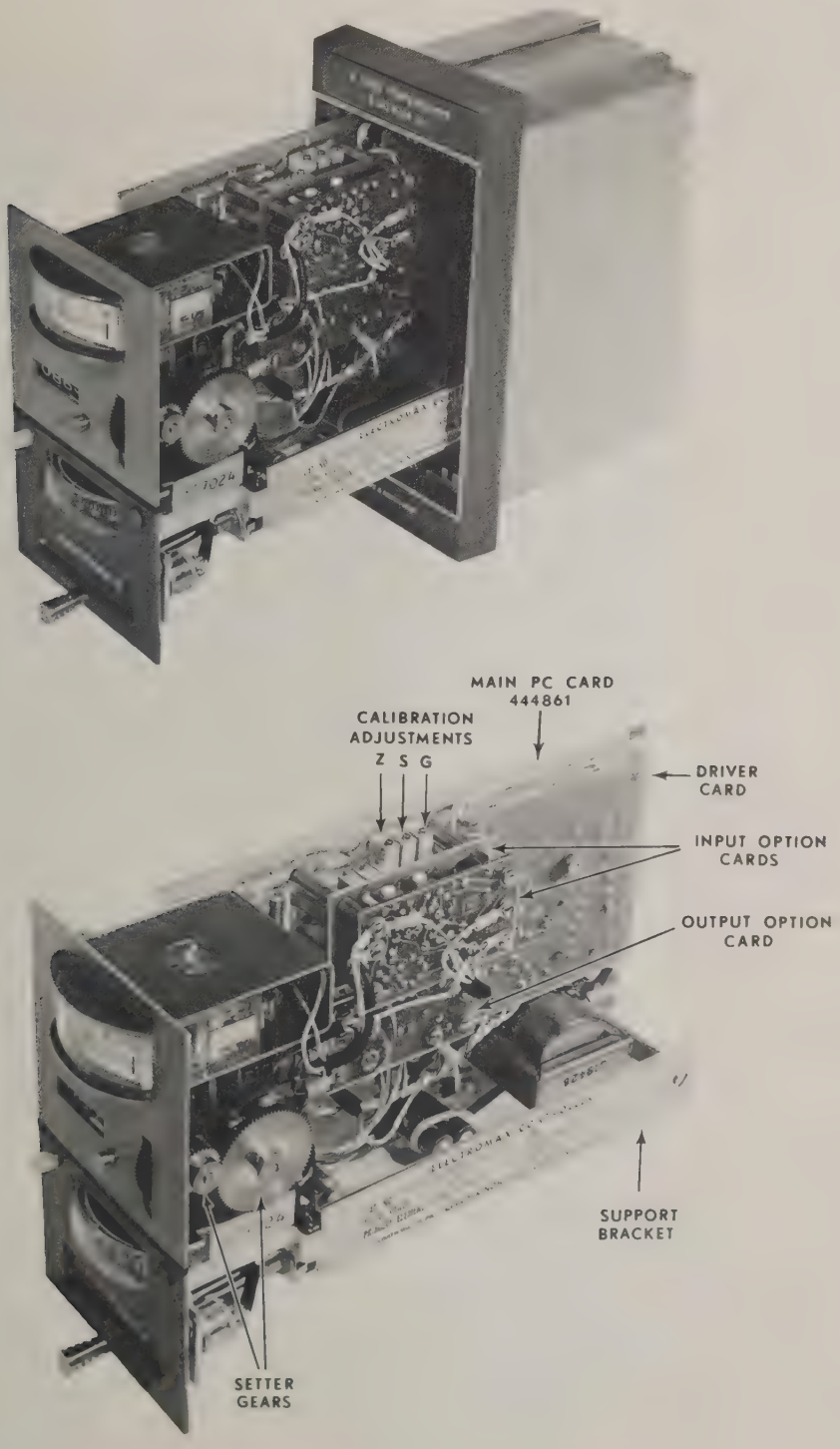

Fig. 5(b)–Controller with digital setter, option and driver cards.

the controller is transferred to the manual mode, where the knob can be rotated to manually change the station output level. The front panel meter normally reads the deviation of the controlled variable from set point, in degrees F or C, or in percent of range. However, when the M button is depressed, the meter indicates the output (50% output at zero center). (See Fig. 5(c), Position C).

The deviation meter is a center-zero meter (2 mA) mounted horizontally above the digital setter or vertically aligned with the axis of the analog setter drum so that the 0 line of the meter coincides with the index line of the drum scale. The mechanical zero-adjustment of the meter is located behind the front panel.

The input or output meter has a zero-centered movement of 500 μA with a linear 0 to 100 scale and is mounted between the setter mechanism and the control adjustment access door. The mechanical zero-adjustment is accessible from behind the front panel.

The control adjustments (screwdriver slots) — Proportional Band, Reset, Rate or Inverse Rate and Approach — as well as Controller Zero and G (R62) are mounted behind a sliding door at the bottom of the front panel. See Fig. 1.

The following controllers have a screwdriver slot adjustment G (R62) for the driver card, mounted in the center position behind the sliding door of the front panel:

CONTROLLER TYPE	ADJUSTMENT FUNCTION OF "G"
6431 - P.A.T.	Gain
6432 - C.A.T. (Hard)	Max. Current Adj.
6433 - D.A.T.	Impulses/minute Adj.
6435 - C.A.T. (Soft)	Max. Current Adj.

Other adjustments can only be reached when the controller is removed from the case or rack. For field adjustments, a card extender (064219) can be used. Red and/or amber lamps are located to the left and right, directly under the setter when specified.

Fig. 5(c) is a front view of a five-position (A to E) multi-pack case. When a position is reversed for future use, a blank front panel is supplied.

(1) PC Card Adjustments

There are three calibration adjustments, set-point span S, zero Z, and amplifier gain G, accessible from the top of the PC card (444861). They are factory-set and normally require no further adjustment. When the controller is mounted in a case, a card extender can be used to make these adjustments accessible while the controller is energized. Fig. 4 shows the location of these components on the 444861 card.

(2) PC Card Jacks

A number of jacks, shown in Fig. 4, are provided on the main PC card to provide a flexible arrangement for various applications. Pairs

E7103

Fig. 5(c)–Multi-Pack Case 10967-5-/□□□□□, where controllers in positions A to E are specified according to Suffix 2 of the multi-pack case catalog numbering code.

of jacks identified by a rectangle around R2, R3, R5, R6 and R34 are for programmable range resistors in the set-point circuit. Standard or reverse acting control is accomplished by a pair of parallel jumpers in the jacks straddled by FWD or RVS. Jacks labeled B-H, J-N, P and U are used to jumper various points on the PC card to selected contacts, J1-J14, for terminal board connection. These jacks are located beneath the driver card, which must be removed if changes are to be made.

In applications where thermocouple failsafe operation is required, a resistor R9 is connected to jack US or DS. The US position causes the controller to react as if the temperature is high when the thermocouple opens.

3B. Option PC Cards

A number of options, such as deviation and input alarms, approach, and input and output meter circuits are provided by PC cards mounted on the input (E1-E7) and output (D1-D7) studs on the main PC card shown in Fig. 4. Fig. 6 shows various combinations specified by the catalog number suffix.

3C. Driver Cards

When specified, a driver card is plugged into the A1-A8 and B1-B8 jacks on the main PC card shown in Fig. 4. In some instances, the controller is used without a driver card, where it operates as a voltage-adjusting-type (V.A.T.) controller with a ±1 mA dc maximum output current. Such an application usually involves an external driver with input characteristics compatible with V.A.T. output specifications.

3D. Reference Junction Compensator Card

The reference junction compensator card is plugged into the terminal board and adjusted from the back of the case, to compensate for the change in ambient temperature.

For any temperature range, the emf input to the controller is a function of the temperature difference between the measuring and reference junctions of the thermocouple. The measuring junction is at the source whose temperature is being detected, and the reference junction is at the controller terminals (13 and 14) to which the thermocouple extension wires are connected. Since any change in temperature at the reference junction will change the effective thermocouple emf, a means for changing the set point emf to compensate for such changes in the thermocouple emf is required. This compensation is automatically accomplished by using an appropriate temperature-sensitive resistor in the reference junction compensator, placing it in proximity to the reference junction so that the same change in ambient temperature causing the thermocouple emf to change will also cause a compensatory change in the set point emf.

3E. Input Ranges

Table I lists the available ranges of the Electromax controller, as well as two calibration points for each range. A calibration table is shipped with each controller for its specified range, and should be used when recalibration is required.

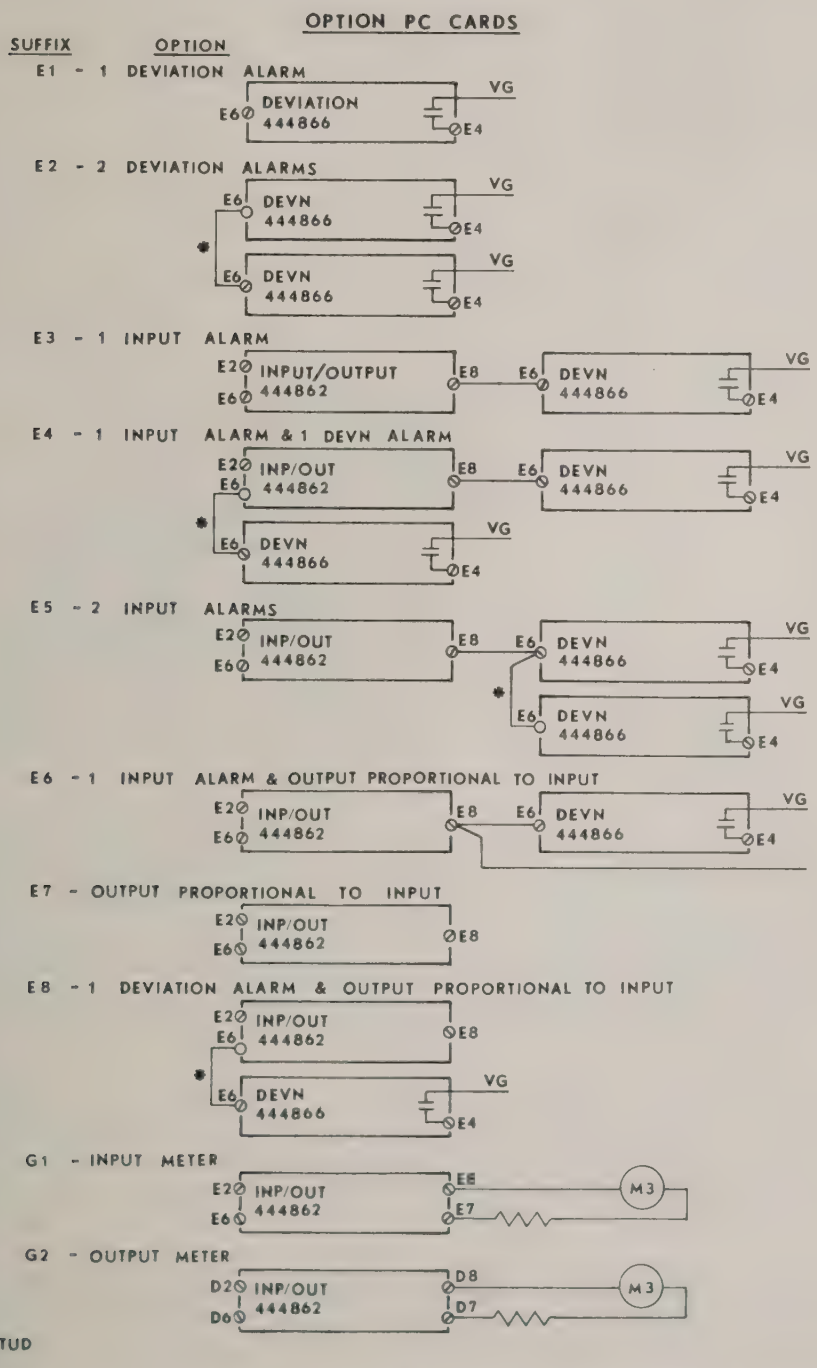

Fig. 6–Connection of option PC cards to main PC-card studs (D&E) to obtain features specified by catalog suffix (E&G). (Studs on left are inputs, on right are outputs.) Output stud E4 is connected to "C" jack on option patch, output lead VG is plugged into option patch, and lead from E8 terminal of I/O card is connected to E6 terminal on DEVN card and/or plugged into option patch.

TABLE I - LIST OF RANGES

Input	Overall Range	Calibrated Range	Calibration Points	Element Number
EMF	-5 to +5 mV	-4.25 to +4.25 mV	-3.5 & +3.5 mV	4046
	0 to 10 mV	3.5 to 6.5 mV	0 & 10 mV	4001
	0 to 10 mV	3.75 to 6.5 mV	0 & 10 mV	4080
	0 to 18 mV	6.3 to 11.7 mV	0 & 18 mV	4079
	0 to 20 mV	7.0 to 13 mV	0 & 20 mV	4002
	0 to 50 mV	17.5 to 32.5 mV	0 & 50 mV	4070
	0 to 100 mV	35 to 65 mV	0 & 100 mV	4003
Pt., 10% Rh-Pt Type S Thermocouple	400 to 2400°F	900 to 2400°F	1000 & 2000°F	4059
	500 to 2500°F	1150 to 2500°F	1600 & 2000°F	4084
	1000 to 3000°F	1250 to 2250°F	1400 & 2000°F	4006
	1000 to 3000°F	1550 to 2800°F	2000 & 2600°F	4004
	0 to 2000°C	450 to 1750°C	550 & 1200°C	4036
	0 to 2000°C	600 to 1700°C	700 & 1300°C	4082
	300 to 1300°C	575 to 1300°C	650 & 1050°C	4093
	500 to 1500°C	625 to 1125°C	700 & 1000°C	4007
	500 to 1500°C	725 to 1425°C	800 & 1300°C	4069
	500 to 1500°C	800 to 1400°C	1000 & 1300°C	4005
Pt., 13% Rh-Pt Type R Thermocouple	1000 to 3000°F	1300 to 2200°F	1400 & 2000°F	4010
	1000 to 3000°F	1600 to 2800°F	2000 & 2600°F	4008
	0 to 1600°C	480 to 1360°C	520 & 1120°C	4142
	0 to 2000°C	400 to 1150°C	500 & 1000°C	4117
	500 to 1500°C	650 to 1100°C	700 & 1000°C	4011
	500 to 1500°C	825 to 1425°C	1000 & 1300°C	4009
Iron-Constantan (Type J) Thermocouple	-100 to 400°F	-12.5 to 387.5°F	25 & 350°F	4049
	0 to 500°F	25 to 200°F	500 & 150°F	4045
	0 to 500°F	25 to 287.5°F	50 & 250°F	4078
	0 to 500°F	75 to 475°F	150 & 450°F	4034
	0 to 600°F	75 to 555°F	120 & 480°F	4050
	0 to 800°F	80 to 740°F	120 & 680°F	4138
	0 to 1000°F	125 to 925°F	250 & 850°F	4041
	0 to 1000°F	425 to 975°F	600 & 900°F	4072
	0 to 1000°F	None	100 & 600°F	4071
	0 to 2000°F	200 to 1400°F	400 & 1200°F	4014
	0 to 2000°F	400 to 2000°F	600 & 1400°F	4012
	200 to 1200°F	275 to 1175°F	350 & 1050°F	4118
	200 to 1200°F	350 to 1150°F	600 & 1000°F	4119
	200 to 2200°F	None	600 & 2000°F	4120
	500 to 1500°F	650 to 1500°F	750 & 1250°F	4023
	-100 to +100°C	-45 to +100°C	20 & 80°C	4134
	0 to 200°C	25 to 185°C	40 & 160°C	4044
	0 to 500°C	50 to 475°C	100 & 450°C	4083
	0 to 500°C	75 to 450°C	200 & 400°C	4121
	0 to 1000°C	100 to 725°C	200 & 600°C	4015
	0 to 1000°C	375 to 900°C	500 & 800°C	4013
Chromel-Alumel (Type K) Thermocouple	0 to 1000°F	100 to 900°F	200 & 800°F	4053
	0 to 2000°F	200 to 1750°F	350 & 1600°F	4018
	200 to 1200°F	325 to 1125°F	400 & 1000°F	4052
	200 to 2200°F	400 to 1900°F	500 & 1800°F	4037
	400 to 1400°F	500 to 1300°F	600 & 1200°F	4051
	500 to 1500°F	600 to 1400°F	700 & 1300°F	4122
	500 to 2500°F	500 to 2200°F	1300 & 2100°F	4016
	1000 to 2000°F	1050 to 1875°F	1200 & 1800°F	4024
	1200 to 2200°F	1225 to 2075°F	1350 & 2000°F	4095

Input	Overall Range	Calibrated Range	Calibration Points	Element Number
Chromel-Alumel (Type K) Thermocouple	0 to 600°C	90 to 570°C	150 & 510°C	4124
	0 to 1000°C	125 to 875°C	200 & 800°C	4019
	0 to 1400°C	140 to 1050°C	210 & 770°C	4056
	0 to 1400°C	140 to 1120°C	280 & 1050°C	4139
	0 to 2000°C	150 to 1350°C	300 & 1300°C	4081
	300 to 1300°C	350 to 1125°C	650 & 1050°C	4017
Copper-Constantan (Type T) Thermocouple	-100 to 400°F	-100 to 400°F	62.5 & 400°F	4042
	0 to 500°F	37.5 to 225°F	50 & 200°F	4125
	0 to 500°F	125 to 500°F	150 & 400°F	4096
	0 to 1000°F	150 to 525°F	200 & 450°F	4020
	-200 to +300°C	0 to 300°C	25 & 200°C	4040
	0 to 200°C	30 to 130°C	40 & 110°C	4055
	0 to 500°C	100 to 325°C	125 & 275°C	4021
	0 to 500 K	237.5 to 462.5 K	250 & 400 K	4126
W, 5% Rhenium-W, 26% Rhenium Thermocouple	0 to 1400°C	210 to 1190°C	280 & 1120°C	4140
	300 to 2300°C	300 to 1500°C	800 & 1400°C	4061
	300 to 2300°C	1100 to 1850°C	1200 & 1750°C	4022
	400 to 1400°C	450 to 1250°C	600 & 1200°C	4060
W, 3% Rhenium-W, 25% Rhenium Thermocouple	1200 to 3200°F	1700 to 2900°F	2000 & 2800°F	4115
W, W 26% Rhenium	300 to 2300°C	1100 to 1850°C	1200 & 1750°C	4145
Platinel II	100 to 1100°C	225 to 950°C	300 & 900°C	4065
	200 to 1200°C	300 to 975°C	400 & 900°C	4127
Pt., 6% Rh Pt., 30% Rh	0 to 1600°C	850 to 1300°C	900 & 1200°C	4141
	0 to 2000°C	950 to 1900°C	1000 & 1800°C	4137
Platinum 100-Ohm Thermohm	-100 to +300°F	-80 to +270°F	-40 & +240°F	4027
	-300 to +100°F	-290 to +70°F	-240 & +40°F	4026
	-300 to +300°F	-300 to +225°F	-180 & +180°F	4028
	0 to 200°F	0 to 180°F	120 & 150°F	4128
	-100 to +100°C	-90 to +85°C	-70 & +70°C	4114
	0 to 100°C	7.5 to 90°C	20 & 80°C	4116
	0 to 200°C	5 to 190°C	20 & 180°C	4129
Nickel 100-Ohm Thermohm	-50 to +250°F	25 to 250°F	40 & 175°F	4029
Copper 10-Ohm Thermohm	0 to 100°C	7.5 to 92.5°C	15 & 85°C	4035
Platinum 25-Ohm Thermohm	0 to 1000°C	0 to 875°C	200 & 800°C	4130

TABLE I - LIST OF RANGES

TABLE I - LIST OF RANGES Con't

Input	Overall Range	Calibrated Range	Calibration Points	Element Number
Ni, -Ni 18% Mo Thermocouple	500 to 2500°F	1150 to 2300°F	1700 & 1900°F	4131
	300 to 1300°C	550 to 1300°C	600 & 1050°C	4132
	300 to 2300°C	900 to 2300°C	1000 & 2200°C	4133
Uncalibrated	0 to 1000 Units	None	None	4030
	0 to 2000 Units	None	None	4031
	0 to 5000 Units	None	None	4032
	0 to 10000 Units	None	None	4033
Differential Temperature Pt., 10% Rh-Pt	±50°C @ 1000°C	See Notes	See Notes	4089
	±100°C @ 1000°C	See Notes	See Notes	4090
High Level	0 to 4 V (100 Units)	0.5 to 3.5 V	0.6 & 3.4 V	4100
	0 to 4 V (200 Units)	0.5 to 3.5 V	0.6 & 3.4 V	4101
	0 to 4 V (500 Units)	0.5 to 3.5 V	0.6 & 3.4 V	4102
	0 to 4 V (1000 Units)	0.5 to 3.5 V	0.6 & 3.4 V	4103
	0 to 4 V (-.5 to +.5)	-0.45 to +0.45 Units	-0.35 & +0.35 Units	4057
	1 to 5 V (100 Units)	1.5 to 4.5 V	0.6 & 4.4 V	4105
	1 to 5 V (200 Units)	1.5 to 4.5 V	0.6 & 4.4 V	4106
	1 to 5 V (500 Units)	1.5 to 4.5 V	0.6 & 4.4 V	4107
	1 to 5 V (1000 Units)	1.5 to 4.5 V	0.6 & 4.4 V	4108
	1 to 5 V (-.5 to +.5)	-0.45 to +0.45 Units	-0.35 & +0.35 Units	4111
	0 to 10 V	0.75 to 9.25 V	1.5 & 8.5 V	4064
High Level pH	0 to 4 V (0 to 10 pH)	1 to 9 pH	1.5 & 8.5 pH	4135
	0 to 4 V (0 to 14 pH)	1.05 to 12.95 pH	2.1 & 11.9 pH	4112
	0 to 4 V (2 to 12 pH)	3 to 10 pH	3.5 & 10.5 pH	4110
	0 to 4 V (4 to 14 pH)	5 to 13 pH	5.5 & 12.5 pH	4143
	1 to 5 V (0 to 10 pH)	1 to 9 pH	1.5 & 8.5 pH	4136
	1 to 5 V (0 to 14 pH)	1.05 to 12.95 pH	2.1 & 11.9 pH	4113
	1 to 5 V (2 to 12 pH)	3 to 10 pH	3.5 & 10.5 pH	4043
	1 to 5 V (4 to 14 pH)	5 to 13 pH	5.5 & 12.5 pH	4144
High Level Ratio	0 to 2 Ratio	.2 to 1.8 Ratio	.3 & 1.7 Ratio	4146
	0 to 2 Ratio	.2 to 1.8 Ratio	.3 & 1.7 Ratio	4147
	0 to 2 Ratio	.2 to 1.8 Ratio	.3 & 1.7 Ratio	4148
	0 to 2 Ratio	.2 to 1.8 Ratio	.3 & 1.7 Ratio	4149
pH Inputs - Option 880	0 to 10 pH	0.75 to 9.25 pH	1.5 & 8.5 pH	4150
	0 to 14 pH	1.05 to 12.95 pH	2.1 & 11.9 pH	4151
	2 to 12 pH	2.75 to 11.25 pH	3.5 & 10.5 pH	4152
	4 to 14 pH	4.75 to 13.25 pH	5.5 & 12.5 pH	4153

Input	Overall Range	Calibrated Range	Calibration Points	Element Number
DIRECT-READING ELECTROMAX III ANALOG RANGES				
The following ranges are characterized, direct reading analog scales - not for use with digital setter or remote setter such as Trendtrak or other device with a nonlinear scale. For these ranges, there are no "calibrated range" or "calibration points". The scales are completely characterized to the appropriate thermocouple curve and set point loading curve. Therefore the overall range and calibrated range are the same. Calibration points are the low and high ends of each span.				
Copper-Constantan Type T	-100 to +400F	---	---	4170
	-100 to +200C	---	---	4171
Iron-Constantan Type J	0 to 500F	---	---	4172
	0 to 1200F	---	---	4173
	0 to 1500F	---	---	4174
	0 to 800C	---	---	4175
NiCr-NiAl Type K	0 to 1200F	---	---	4176
	0 to 1500F	---	---	4177
	0 to 2000F	---	---	4178
	0 to 2400F	---	---	4179
	1000 to 2000F	---	---	4180
	0 to 1200C	---	---	4181
Pt, 10% Rh-Pt Type S	0 to 3000F	---	---	4182
	1000 to 3000F	---	---	4183
	0 to 1600C	---	---	4184

TABLE I - LIST OF RANGES (Continued)

PART II INSTALLATION

4. UNPACKING

The following documentation is supplied with each Electromax III:

Direction Book 177584

Controller schematic without driver—D-D-2567-70

Applicable driver schematic—C-D-2567-7X

Computerized installation diagram for specific controller

Calibration Table for controller range

Instrument data sheet

Mounting dimension drawing—H-DIM-2567-70

The above information is up-to-date and applies specifically to your instrument. If a discrepancy occurs between the direction book and the other sources of information, the latter should be considered the most up-to-date. This is because the direction book has a long reprint cycle and revisions do not appear until a subsequent printing.

The instrument data sheet describes the type of controller or alarm unit, its various features, input range, and a list of jumper and resistor positions which have already been installed (for verification only).

The dimension drawing and installation diagram contain details for mounting and wiring the controller or alarm unit. Read notes on each carefully. See Sections 5 to 7 for procedures and general discussion.

The calibration table supplied with the instrument typically shows the mV, temperature and its difference from the setter setting value at each equally-spaced setting of the setter over the specified overall range. The two asterisks (*) indicate the high and low calibration points of the ±1% range. The high and low end values are the limits of the overall range of the setter.

When the case and controller or overheat alarm unit are specified, they are normally packed together. In order to separate them, cut and remove two shipping straps; one is looped around the terminal board at the back of the case and through a hole in the main PC card of the controller, and the other is looped around the front panel of the controller. Follow all instructions on tags attached to either the case or controller before removing the tags. Check all plug-in components and interconnecting wires to make certain that they are firmly connected and that all stud screws (14) are tight. MAKE SURE THAT THE SERIAL NUMBER OF THE CONTROLLER IS THE SAME AS THAT OF THE CASE*.

*Although it is not recommended, controllers can be interchanged in a given case provided that each compensator is used with the particular controller with which it was shipped. Otherwise, the controller must be recalibrated.

5. MOUNTING THE CASE

The controller case is designed for flush-mounting on a panel. For best performance, locate the controller in an area where the ambient temperature is within 40° to 120°F. Prolonged operation at the extreme limits of 32° and 140°F is not recommended. Low temperature storage (0°F) is not harmful.

Power from a 107 to 127 V, 50/60 Hz line is required for operation of the controller.

To mount the case:

(1) Cut an opening in the panel for the case, as shown in Fig. 7(a).

(2) Remove the cover from the rear of the case*, the two jacks and jack screws, and slide the case through the panel from the front.

(3) At the rear of the panel, hold the case perpendicular to the panel, slide the jacks into the outside case guides, and tighten the jacks against the back of the panel by screwing each jack screw in the hole at the back of the case until the jacks draw the case firmly against the panel.

(4) Slide controller into case until its contacts are firmly engaged by the case connector. If a compensator was removed during the installation, plug it into its position (terminals 10-14) to the left of the case terminal board. In the ON-OFF, D.A.T. and P.E.T. controllers, a triac assembly is normally mounted in the rear of the case and its leads are connected to the terminal board (shown on the installation diagram). See Fig. 7(a) for locations. For a 10967 Multi-Pack Case, refer to Fig. 7(b) for panel cut-out and installation dimensions. If compensators are provided, make sure that each compensator is plugged into the terminal board of its associated controller case.

6. WIRING PROCEDURES

The following wiring procedures must be adhered to in order to obtain the performance described in the Specifications enclosed in this book. The most important wiring considerations are proper grounding, input wiring segregation and arc suppression of inductive loads.

6A. Grounding

Although the Electromax III controller may be operated without a ground connection to the circuit, best performance is achieved when the control loop is connected to a solid earth ground. The ground used should be an "Instrument Ground" bus or other bus tied directly to earth. (A copper water pipe often provides an excellent earth ground.) When an instrument ground or other preferred ground is not available, the ground lead (conventionally a green wire) of the 120 volt supply may be used.

*If a compensator is present, it may have to be removed.

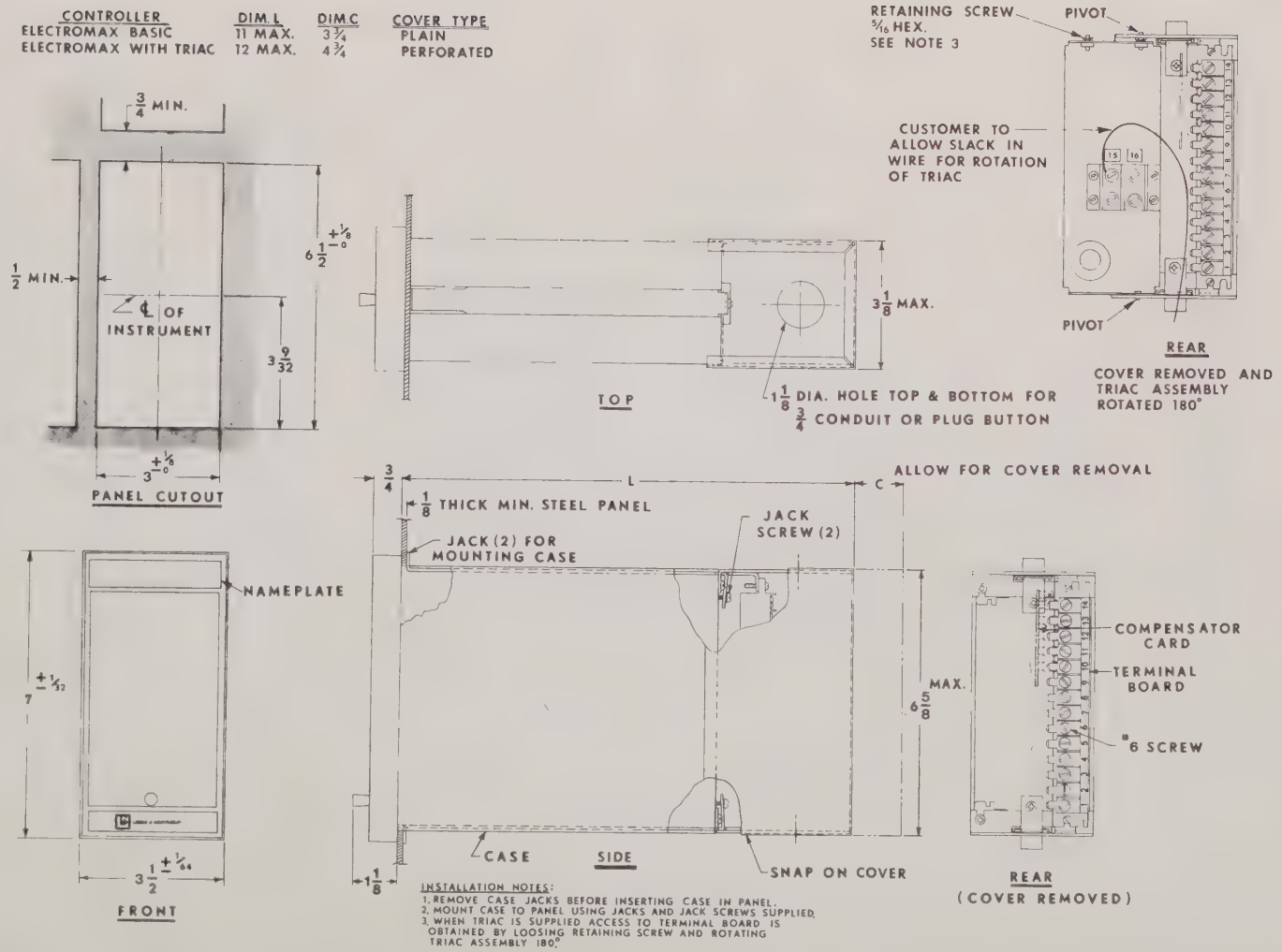

Fig. 7(a)—Panel cutout and dimensions diagram.

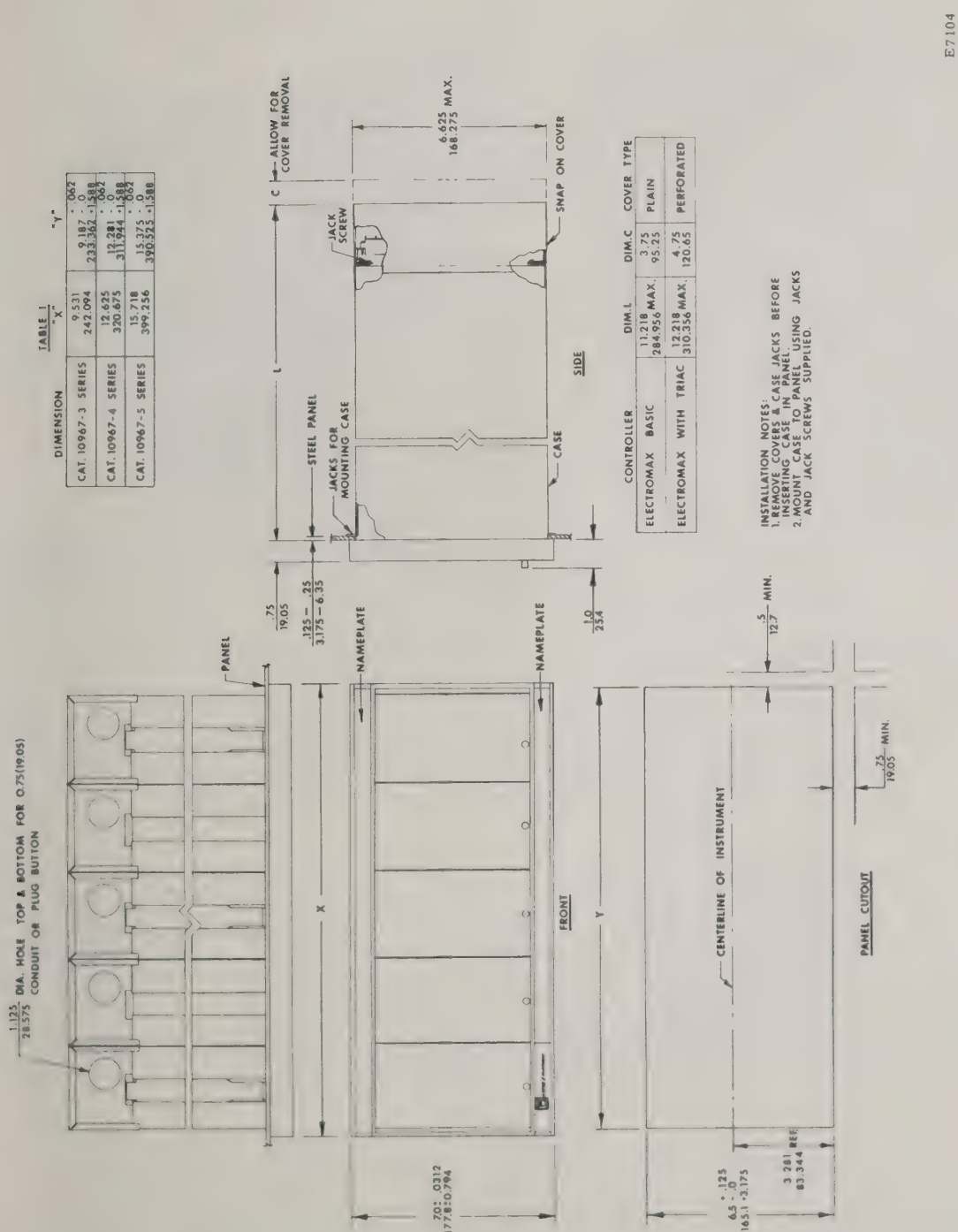

Fig. 7(b)–Panel cutout and dimensions diagram of multi-pack case.

UNDER NO CIRCUMSTANCE SHOULD THE NEUTRAL SIDE OF THE POWER SUPPLY LINE BE USED AS A GROUND CONNECTION.

For personnel safety the CASE of the controller should always be connected to a solid ground. Do not rely upon the mounting structure (steel panel, etc.) to provide a good case ground. To connect the case to ground, connect a ground lead to one of the four screws at the rear corners of the case. DO NOT USE THE TERMINAL BOARD MOUNTING SCREWS FOR THIS CONNECTION.

Before grounding the control circuit, specific consideration must be given to the entire loop. When neither input nor output of the controller is grounded, connect a jumper from terminal 9 to the case ground screw noted above*. Care must be taken to avoid ground loops by grounding the equipment at only one point. If the input is grounded—either permanently or intermittently, or the output circuit is grounded (C.A.T. or V.A.T. only) do NOT connect a ground jumper to terminal 9. Under this condition, two 4 μF capacitors (023410) should be connected from terminal 14 to case ground screw, and 13 to case ground screw. Note that this ac ground does not eliminate interference if the input source "ground" should have a large ac signal with respect to the controller ground. In such cases a controller with input-output isolation (e.g., Electromax IV) should be used.

The terminal board at the rear of the case is shown in Fig. 7(c).

6B. Input Wiring

The input signal wires, such as thermocouple wires and P.A.T. feedback wires, MUST NOT BE RUN PARALLEL OR IN THE SAME CONDUIT WITH THE AC POWER LINES, in order to avoid coupling high-level ac signals into the low-level input lines.

6C. Arc Suppression

An arc suppression circuit is required when an inductive load (i.e., contactor coil) is connected to the relay output of the D.A.T. or ON-OFF controller without triac assembly or the overheat alarm unit. Arc suppressors 171070 (0.02 μF and 330 ohms in series) across relay contact terminal board terminals prolong contact life and minimize RFI generation**. Presence of excessive RFI is detected by sporadic movement of the deviation meter needle, unrelated to input signal changes.

If the deviation or input alarm contacts operate as inductive load, the same circuitry must be applied across the reed relay contacts**.

If a triac assembly is used with the D.A.T. or ON-OFF controller, the above protection is not required. However, it is desirable to connect

*With Option 880, DO NOT GROUND TERMINAL 9.

**Suppressors are supplied with the controllers, when required.

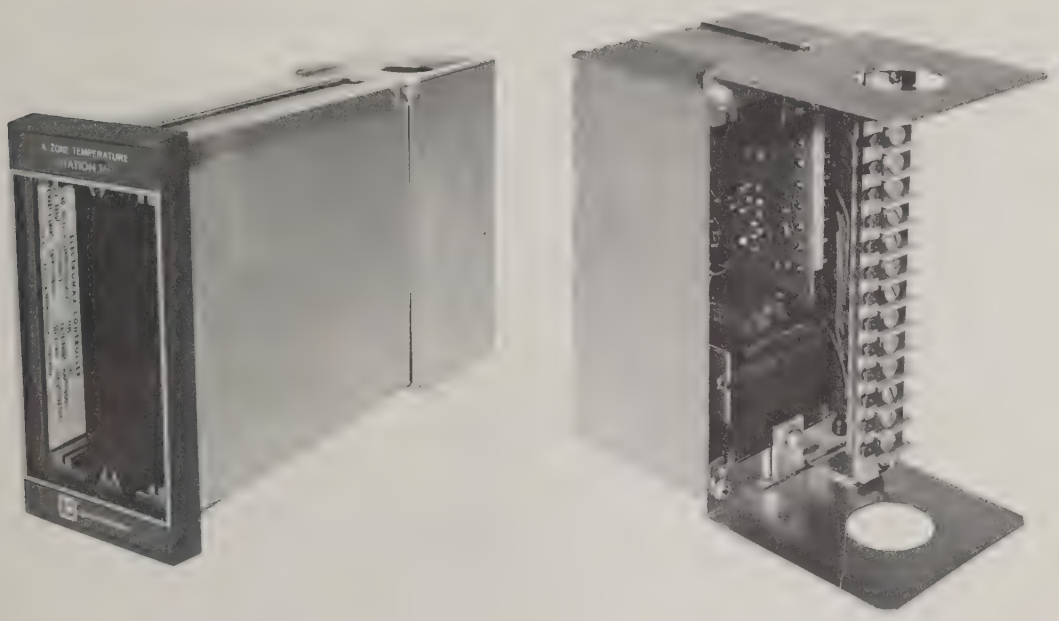

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Fig. 7(c)–Front and rear views of case.

arc suppressors directly across any contactor coils that are operated by the triac assembly. This is especially important when both contactor and controller are operated from the same power line. The larger contactors should be equipped with 1.0 μF/400 V capacitors and 47 ohm/2 W resistors in series.

6D. Line Filters

Where excessive rf noise exists on the line, it can be improved by mounting a line filter (171071)* at the rear of the controller case, connecting its lugs to terminals 1 and 2, and connecting the line to terminals 1 and 2 of the filter. Any other connections normally made to terminals 1 and 2 of the terminal board must be made to 1 and 2 of the filter.

> CAUTION: A dangerous voltage (65 V ac) can develop on the controller case, unless the case is carefully grounded. The power supply should not be grounded separately.

6E. Thermocouple Compensator Cards

A TC compensator card is provided with each controller with a specified thermocouple input range, with the exception of type B thermocouples. When type B thermocouples are specified, a jumper is provided between case terminals 11 and 12.

* Purchased separately.

TABLE II–INSULATION COLORS OF L&N THERMOCOUPLE EXTENSION WIRES

THERMOCOUPLE		POL.	EXTERNAL EXTENSION WIRE*			
ISA TYPE	TYPE OF WIRE		TYPE OF WIRE	SINGLE CONDUCTOR	DUPLEX CABLE	
					INNER	OUTER
E	Chromel Constantan	+ –	Chromel Constantan	Yellow Red-Blue	Violet Red	Brown
J	Iron Constantan	+ –	Iron Constantan	White Red-White	White Red	Black
K	Chromel Alumel	+ –	Chromel Alumel	Yellow Red-Yellow	Yellow Red	Yellow
R	Plat. +13% Rhod. Platinum	+ –	Copper Alloy	Black Red-Black	Black Red	Green
S	Plat. +10% Rhod. Platinum	+ –	Copper Alloy	Black Red-Black	Black Red	Green
T	Copper Constantan	+ –	Copper Constantan	Blue Red-Blue	Blue Red	Blue

* For Chromel-constantan thermocouple, L&N supplies thermocouple wire instead of extension wire.

There are three types of TC compensator cards: namely, the early production type 444867 (Rev 3), which caused an offset voltage problem due to contact resistance of the terminal board fingers at terminal 14 (input common); the modified type 444867S (Rev 4), which corrects the problem by cutting the foil on the 444867 (Rev 3) card between TPB and its female connector engaging the spade lug of terminal 14, and soldering a white lead to TPB and connecting the free end to terminal 9 (output common); and type 445089, which incorporates the modification of the 444867S (Rev 4) card plus additional regulation (2 zener diodes) to permit interchanging controller chassis of the same input range without recalibration.

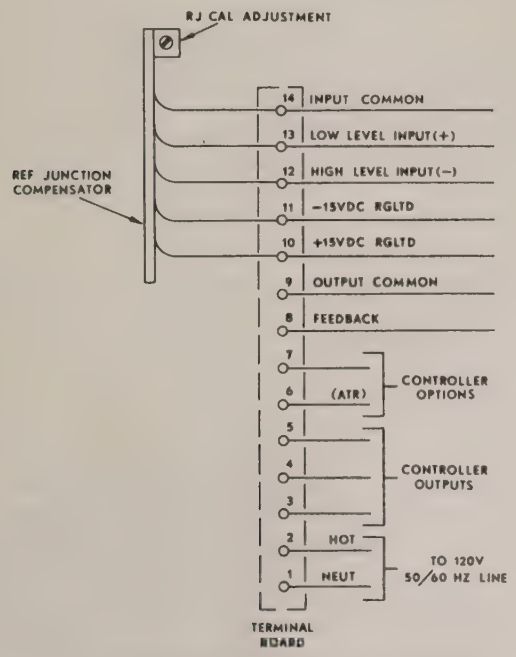
7. WIRING

After removing the rear cover and plug buttons from the rear of the case, install conduit (if required) and necessary external wiring, and make all connections at the case terminal board. Follow wiring procedure outlined in Section 6.

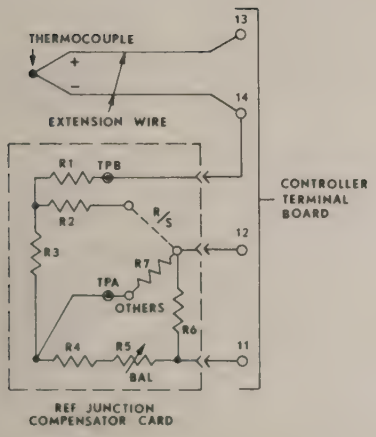
Make terminal connections in accordance with the installation diagram supplied with the instrument. See Table II for color coding of thermocouple extension wire, and Fig. 8 for terminal board designations and typical input connections. When fuses or line switch are required, they must be provided externally by the user.

7A. Control Action

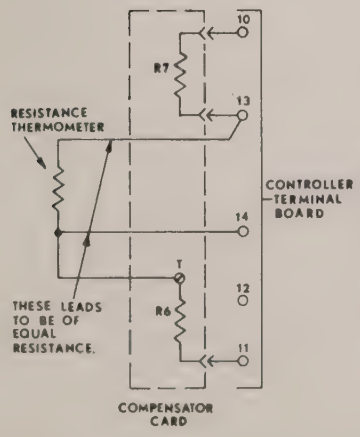
The controller is shipped with standard (forward-acting) control or reverse-acting control as specified (Suffix F). In standard control the final control element reduces the controlled variable when the input signal increases, whereas in reverse control the final control element increases



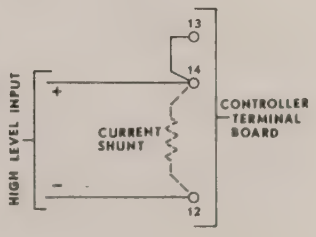
CONTROLLER TERMINAL BOARD DESIGNATIONS



THERMOCOUPLE CONNECTIONS



THERMOHM CONNECTIONS
2R6=R7



TRANSMITTER CONNECTIONS
(HIGH LEVEL VOLTAGE)

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Fig. 8–Controller terminal board designations and input connections.

the controlled variable when the input signal increases. To change from one type of control to the other, remove the driver card, move the two jumper leads from the FWD to the RVS jacks or vice versa, and reverse the leads to the input, deviation meter and input meter. Replace the driver card on the main PC card and the controller in the case.

7B. Line Voltage Connections

Connect the ac line to terminals 1 (Neutral) and 2 (Hot) on the terminal board. If ac power is also required for the output circuit, a separate ac line can be connected to the appropriate terminals, or insulated jumpers can be used from terminals 1 and 2.

7C. Input Connections

For a temperature range, connect the thermocouple extension wires (twisted) or duplex cable (parallel) to terminals 13 (+) and 14 (–) for standard control action.* When the failsafe feature is required, plug the free end of resistor R9 into US jack for upscale protection, and into DS jack for downscale protection. When failsafe is not to be used, plug R9 end in NC jack. These jacks and R9 are on the main PC card under the driver card (Fig. 4).

For a millivoltage input range, connect a twisted pair of copper wires between the emf source and terminals 13 (+) and 14 (–) for standard control action.* Connect a jumper between terminals 11 and 12.

For a voltage or current (mA) input range, connect the high-level input to terminals 12 (–) and 14 (+) for standard control action.* Connect a jumper between terminals 13 and 14.

For a pH input with Option 880, connect the pH transmitter to the X terminal of the (445259) pH input card and signal common terminal 14 at the rear of the Electromax III case. Terminals Y and Z provide the +15 V and –15 V dc, respectively, to the transmitter. See Fig. A8 in Appendix. Since trouble could occur, if the potential of the solution is more than 5.0 volts ac above an earth ground potential, common mode voltages greater than 5 volts ac should not be permitted. Since neither the 7773 nor the 7779 transmitter provides electrical isolation (input to output) the normal procedure of grounding terminal 9 on the Electromax III (either directly or through a capacitor) must not be followed in these applications. The circuitry on all such installations must be left floating. However, the case should always be grounded as a personnel safety precaution.

7D. Controller Options Connections

Consult the computerized installation diagram for the correct option connections.

*Reverse the polarity for reverse control action.

7E. Output Connections

The output connections are determined by the type of controller specified. See specifications of particular driver for load restrictions and installation diagram supplied with the instrument.

(1) 6430 V.A.T. Controller

Connect the external load (10k ohm min) to case terminals 5 and 9 (SC). Note: Output voltage is driven positive with positive-going input signal for standard control action.

(2) 6431 P.A.T. Controller

Connect the winding leads of the bidirectional motor of the drive unit to terminals 3 (Decrease) and 5 (Increase)* and the common motor lead to the line voltage (drive unit supply) neutral lead. Connect the hot lead of the line voltage (drive unit supply) to terminal 4. Note: The triac output is isolated from the dc input signal of the controller.

> CAUTION: Double check the above connections before applying power. The triac switches will fail instantly if a short-circuit current flows from terminals 3 to 4 or 5 to 4.

Connect the slidewire arm of the drive unit to feedback terminal 8. Connect the "closed" end of the slidewire to output common 9 and the "open" end to -15 V dc at terminal 11 (or terminal 10 for reverse acting control). These connections provide a feedback voltage with a negative polarity as required by the control circuit.

(3) 6432 (Hard) and 6435 (Soft) C.A.T. Controllers

Connect the external load to output terminal 5 (+) and output common terminal 9. The output is not isolated from the input, but is referenced to the input common. Cascading of one controller to another is, therefore, straight forward, and can be accomplished through the cataloging system (Suffix J). The output current range is determined by the catalog number and may be changed by means of a jumper on the driver card.

(4) 6433 D.A.T. Controller

(a) Relay-Output Driver with Triac Assembly

Connect the hot side of the 120 V ac line to terminal 15 on the triac assembly, and one side of the load to terminal 4 of the controller. Connect the other side of the load to the neutral side of the line. Terminal 16 can be used as a tie point.

A triac assembly, Part No. 173071** (1 kW at 120 V ac, 10 W min.) is normally used with this controller, but it must be specified. Connect the tagged leads to the corresponding case terminals.

*Reverse leads for reverse acting control.

**A dual triac assembly is used when option 870 is specified.

(b) Relay-Output Driver without Triac Assembly

Connect the hot side of the 120 V ac line to terminal 5 on the terminal board, and one side of the load to terminal 4 of the controller. Connect the other side of the load to the neutral side of the line. An arc suppressor (171070) is supplied across terminals 4 and 5. Maximum ratings: 10 W, 135 V ac/200 V dc, 0.5 A. DO NOT EXCEED ANY OF THESE RATINGS (i.e., at 120 V ac the maximum current must be less than 0.083 A to keep within the 10 W rating. P = EI).

(c) Solid-State Output (Suffix J805)

Make output connections as in (b), except that arc suppressor is not supplied, and maximum output ratings are 100 W, 1 A and 120 V (ac only). Use external relay for dc applications.

(5) 6434 P.E.T. Controller (Triac Output)

Connect the hot side of the 120 V ac line to terminal 3 and one side of the load to terminal 15 on the triac assembly. Connect the other side of the load (up to 1 kW, but not less than 250 W) and the neutral of the ac line together at terminal 5. Note: The controller output is isolated from the input.

A triac assembly, Part No. 173072*, should be used with this controller, but it must be specified (Suffix H). When supplied, it is mounted at the rear of the case. However, it can be mounted remotely, if conditions require it. Connect the tagged leads to the corresponding case terminals.

(6) 6437 ON-OFF Controller

Connect as in Section 7E (4).

(7) 6438 Overheat Alarm

Connect one side of the 120 V ac line to terminal 4. Connect the other side of the line to one side of the load. Connect the other side of the load to terminal 3 for normally-closed contact, or to terminal 5 for normally-open contact. See schematic diagram at the back of this book for details. Arc suppressors are supplied between terminals 3 and 4, or 4 and 5. Contacts are rated at 3 A, 150 V ac max.

Connect the input to terminals 13 (+) and 14 (–) when standard overheat (Suffix F-0), underheat with automatic reset (F-2) or underheat with power failure trip (F-4) is used. Connect the input to terminals 13 (–) and 14 (+) when standard underheat (F-1), overheat with automatic reset (F-3) or overheat with power failure trip (F-5) is used.

(8) Deviation And/Or Input Alarms

A maximum of three cards can be stacked on the E studs on the main PC card for various combinations of deviation and input alarms. A deviation alarm circuit consists of one 444866 card, whereas an input alarm circuit consists of one 444862 (I/O) and one 444866 card.

*A dual triac assembly is used when option 870 is specified.

The circuits can be identified by the relative positions of the alarm cards with respect to the main PC card and the I/O PC card (Inboard is the card position nearest the main PC card), as shown below:

SUFFIX	CARD POSITION	CIRCUIT DESIGNATION
	Main Card	
E2	Alarm Card	(Inboard) Deviation Alarm
	Alarm Card	(Outboard) Deviation Alarm
G1 or E7	I/O Card	
	Main Card	
	Alarm Card	(Inboard) Deviation Alarm
E4	I/O Card	
	Alarm Card	(Outboard) Input Alarm
	Main Card	
	I/O Card	
E5	Alarm Card	(Inboard) Input Alarm
	Alarm Card	(Outboard) Input Alarm

Since there are many combinations of deviation and input alarms possible, follow the installation diagram supplied with the controller to make the correct external connections. Pay particular attention to the notes on the diagram which indicate whether the relay contact is isolated or whether it is connected to the internal 30 V dc, 25 mA supply. The contact is rated at 10 W* max, 0.5 A max, 120 V ac or 200 V dc max, and is shunted by an arc suppressor (171070).

8. PRELIMINARY ADJUSTMENTS

The controller or alarm unit has been calibrated at the factory in accordance with its catalog number and therefore requires no further adjustment. If calibration becomes necessary, refer to Section 21 for calibration procedure.

Deviation and input alarm adjustments are described in Sections 8A and 8B, and tuning control adjustments in Part III - Operation.

8A. Deviation Alarm

When a deviation alarm card is provided, the high and low alarms can be set by adjusting setters A and B. The deviation alarm card is mounted on the E studs on the main PC card (Fig. 4). Setters A and B are adjustable from the top of controller when it is withdrawn from the case. (A is closest to front of controller.)

Control action determines which setter is used for the high and low alarm. When only one alarm is to be used, one of the input diodes must be shorted out on the deviation alarm card. This is already done when option 836 (alarm below set point) or 837 (alarm above set point) is specified.

*Caution: Do not exceed any of the maximum ratings; at 120 V ac the maximum current is limited to 0.083 A (P = EI).

CONTROL ACTION	LOW ALARM SETTER	HIGH ALARM SETTER	LOW ALARM ONLY	HIGH ALARM ONLY
Standard (Fwd)	B (R2)	A (R5)	Short CR5	Short CR6
Reverse	A (R5)	B (R2)	Short CR6	Short CR5

To adjust the alarm setters A and B to the desired deviation limits, use a card extender to permit setter adjustment while the controller is energized. Adjust the set point to obtain each desired deviation alarm setting and adjust A and B until alarm action occurs at each setting. The high and low alarm settings should not be set closer than 10 degrees from each other. If a card extender is not available, remove the controller from the case to adjust setters A and B approximately. Then place the controller back in the case, adjust the set point for the desired deviation and note alarm action. This procedure may have to be repeated several times before the correct settings are obtained. The limit of setting is ±50° for temperature controllers.

8B. Input Alarm

The input/output card (444862) has been factory calibrated to provide a 0-5 V dc output (E8) proportional to the input signal. The input (E6) of the deviation alarm card (444866) is connected to the output (E8) of the input/output card. Adjust the input signal to obtain the desired input alarm setting, and adjust setter A (for standard-acting control) or setter B (for reverse-acting control) until alarm action occurs. The limit of range is 0-100% of set point (nominal marking is 0-50).

8C. Reversing Control Action

To change the control action of the controller from direct (forward) to reverse,

(1) Change the two jumpers on the controller from FWD to RVS positions (Fig. 4), and reverse the meter leads at E6 and E7 studs (V & B leads with or W & K leads without, manual station). On Option 880 (pH input card) remove jumper W1 (forward) and add jumper W2 (reverse).

(2) Reverse input connections to reverse polarity. On Option 880, do not reverse input connections. On 6431 (P.A.T.) units, transfer drive unit slidewire lead from controller case terminal 11 to 10 (-15 V dc).

(3) On thermocouple applications, adjust compensator voltage (Table V).

(4) Remove red lead temporarily from lefthand jack of R3 (Fig. 4) (Option 880 only). Adjust Z (R7) on controller PC card per Sec. 21C. DO NOT ADJUST S(R1) OR G(R16). Replace red lead in R3 jack (Option 880 only).

(5) Recalibrate the unit as per Sec. 21. Except for the range zero adjustment, only minor readjustment will generally be necessary.

To change the control action of the controller from reverse to direct, reverse the procedure in steps (1), (2) and follow steps (3) to (5).

8D. Changing Ranges*

1. New plug-in resistors are usually required in positions R2, R3, R5, R6 and R34 on main PC card. See Fig. 4 for location and Table AIV for part number.

2. Recalibrate controller as per Section 21.

8E. pH Calibration

To calibrate the Electromax III for a pH range;

(1) Place the pH electrode in a known pH solution.

(2) Adjust the set point to the pH value of the solution.

(3) Adjust the right hand control STD behind the front panel door until the deviation meter deflection is 0. When this condition can no longer be obtained, it is time to change or clean the electrodes.

> NOTE: The controller has been calibrated with STD disconnected. Therefore, trimpots Z (R7), S (R1), and G (R16) should not be disturbed, unless the controller is to be completely recalibrated (See Section 21).

*May require new counter or scale.

PART III OPERATION

9. OPERATION

If applicable, make these initial control settings: P.B. at 100, RESET at 0.1, RATE/LAG (INV. RATE) at 0, and APPROACH at 0.

After the controller and other components of the control loop have been installed and prepared for operation, apply ac power, push the set point lock button, and turn the thumbwheel until the set point scale or counter registers the desired set point. Since the controller has a linear set-point potentiometer for temperature ranges, counter settings do not agree with temperature over the entire range; to determine the exact counter setting required for any desired set-point temperature, refer to the table supplied with the controller. For controllers with millivoltage ranges, the counter setting represents millivolts within 1% of input span.

The deviation of input from set point is indicated by the deviation meter. For any temperature range, the meter reading is the deviation in degrees. For the millivoltage range, the meter reading divided by 100 is the deviation in millivolts.

The input or output meter indicates the input or output signal, depending upon which is specified.

If the controller has a P.A.T. or soft C.A.T. manual station (G4 or G5):

(1) Depress the A button to transfer the controller to the automatic mode.

(2) Depress the L button again to transfer to the manual mode and gradually reduce the controller output or move a drive unit toward the closed valve position until the button is released. It remains in the manual mode until the A button is depressed.

(3) Depress the R button to transfer to the manual mode and gradually increase the controller output or move a drive unit toward the open valve position until the button is released. It remains in the manual mode until the A button is depressed.

(4) Depress the M button to indicate the output of controller or the position of the valve on the deviation meter. When the button is released, it indicates the deviation of the controlled variable from set point.

If the controller has a hard manual station (G3):

(1) Depress the A button to transfer the controller to the automatic mode.

(2) Depress the A button again to transfer the controller to the manual mode. The knob between the A and M buttons can be rotated to change the controller output.

(3) Depress the M button to indicate the output of the controller. When the button is released, it indicates the deviation of the controlled variable from set point.

The controller output varies with the input signal as described below. See Fig. 2 for input-output relationships.

9A. Basic (V.A.T.) Controller

When the input goes below set point, the output voltage goes negative in proportion to the deviation. When the input goes above set point, the output voltage goes positive in proportion to the deviation. At set point, the output is constant. The maximum output voltage is ±10 volts into a 10kΩ (minimum) resistive load.

9B. P.A.T. Controller

When the input goes above set point, the neon lamp is lit and 120 V ac is applied to terminal 3 to energize the decrease winding of the drive unit motor. When the input goes below set point, the neon lamp goes out and 120 V ac is applied to terminal 5 to energize the increase winding of the drive unit motor. At set point, the neon lamp should be on, the 120 V ac removed from terminals 3 and 5, and the motor windings de-energized. If the lamp goes on and off in a rapid sequence which indicates hunting, adjust the gain control G behind the front panel door until the lamp stays on with the controlled variable at or above set point.

9C. C.A.T. Controllers

When the input goes below set point, the output current increases. When the input goes above set point, the output current decreases. At set point, the output current is constant.

9D. D.A.T. and P.E.T. Controllers

When the input goes below set point, the power output to the load increases. When above, it decreases. At set point, power output remains constant.

9E. ON-OFF Controller

When the input is below set point, the line voltage is applied continuously to the external load and the amber lamp is lit. At set point and above, the amber lamp goes out and the load voltage becomes zero.

When Suffix D1 is specified, two deadband adjustments are provided behind the front-panel door; R is the centering control and A is the width control.

9F. Overheat and Underheat Alarms

The state of the output relay under normal, alarm and reset conditions for the six overheat and underheat types are as shown below: (Alarm condition is indicated when the red lamp is lit.)

SUFFIX F	NORMAL CONDITIONS INPUT	NORMAL CONDITIONS RELAY	ALARM CONDITIONS INPUT	ALARM CONDITIONS RELAY	LATCHED CONDITIONS INPUT	
0	Below Set Point	De-energized	Above Set Point	Energized	Below Set Point	Push PB2 to de-energize relay.
1	Above Set Point	De-energized	Below Set Point	Energized	Above Set Point	
2	Above Set Point	Energized	Below Set Point	De-energized	Above Set Point	Automatically energized.
3	Below Set Point	Energized	Above Set Point	De-energized	Below Set Point	
4	Above Set Point	Energized*	Below Set Point	De-energized	Above Set Point	Push PB1 to energize relay.
5	Below Set Point	Energized*	Above Set Point	De-energized	Below Set Point	

*Initially reset by pushing PB1.

10. ADJUSTMENT OF CONTROLLER TO A PROCESS

While theoretical methods have been devised for determining initial control settings, experience has shown an experimental approach to be the most practical and least time consuming for most installations. Such an approach requires principally the recognition of basic symptoms of incorrect adjustment, from the recorder chart or deviation meter, and only moderate skill on the part of the operator. The effects of various control settings are shown in Figs. 9(a) to 9(d).

In making progressive adjustments, particularly in temperature control applications or other slow processes, allow sufficient time between adjustments to permit conditions to stabilize. Failure to do so may lead to wrong conclusions about the effect of the last change in control settings, and frequently results in loss of time in "tuning" the controller to the process.

For some processes where operating conditions vary widely, it may be necessary to make final adjustments which are a compromise for best overall control action. In any case, it is good practice to avoid tuning the controller to a point of sensitivity where minor changes in process conditions can introduce a cyclic system response. In general, good control settings are those which produce satisfactory results without sacrifice of control stability.

After the best settings have been determined, they should be recorded to facilitate resetting if the controls are subsequently disturbed in any way.

10A. Proportional Band

As the Proportional Band setting is decreased, the change in final control element position increases per given controlled variable or set point change. Before making the initial proportional band adjustment, the controller settings should be as listed in Section 9.

The bumpless method* of finding the initial Proportional Band setting is to progressively decrease the Proportional Band setting with the controller in the manual mode and observe the effect of each decrease on the deviation meter (or recorder chart, if available) with the controller in the automatic mode, until the system cycles steadily. To transfer to the automatic mode, depress the A button. To transfer to the manual mode, depress A again (G3), or depress L or R momentarily (G4 or G5). Allow sufficient time after each adjustment for the system to stabilize. When the system is cycling steadily, note the frequency of the cycle and increase the Proportional Band until the cycling stops. Fig. 9(a) shows the effects of various Proportional Band settings in a typical temperature control system.

10B. Rate

As the Rate Time setting is increased, the amount of change in final control element position increases for a given controlled variable or set point change.

Determine the initial Rate setting by obtaining the open-loop response of the controlled variable to a step change in process input. This is accomplished in the manual mode by shifting the value of the controlled variable or set point and observing the controlled variable on a recorder chart.

(1) Draw a tangent through the steepest slope portion of the curve as shown in the typical response curve of Fig. 10(a), and determine ΔC.

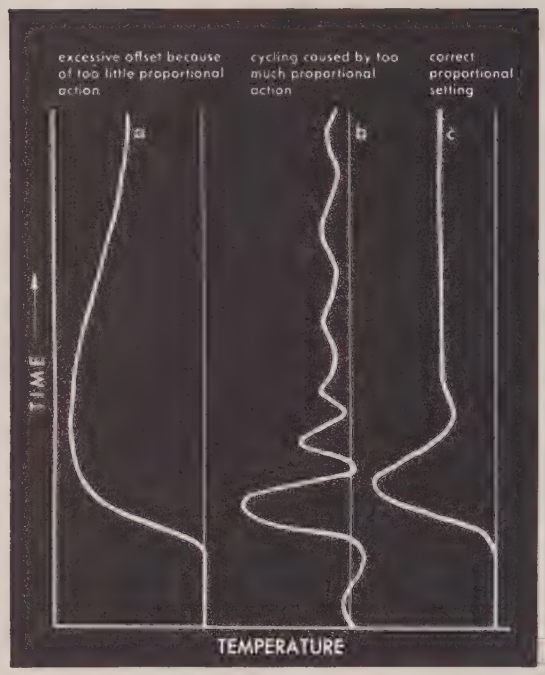
(2) Measure T_1 and T_2, where T_1 is the delay time and T_2 is T_1 plus the rise time to 60% of the output change.

(3) Calculate the ratio of T_1/T_2 and obtain the value of TR/T_2 from the curve in Fig. 10(b).

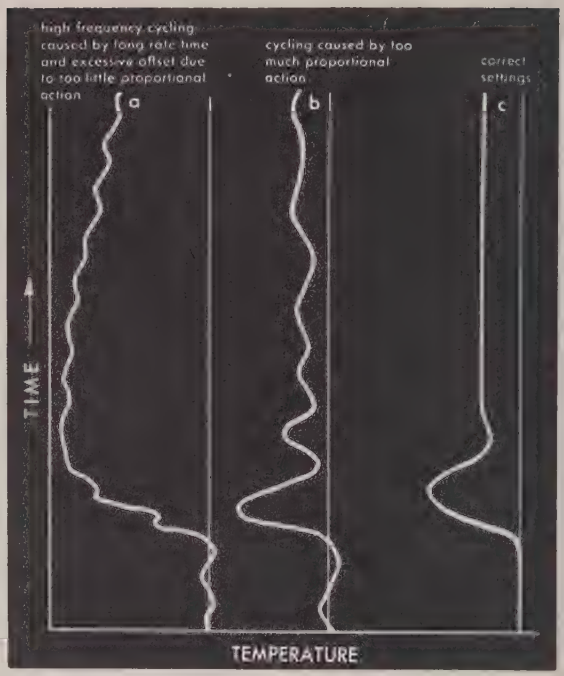
(4) The Rate Time setting is determined by multiplying TR/T_2 by T_2. With the initial Proportional Band and Rate settings as determined above, introduce minor upsets in the system by making small changes in Proportional Band. If cycling develops at a higher frequency than that produced

*If the Proportional Band setting is changed with the system in the automatic mode (no manual station), the drive unit or output signal will respond. When the reset setting is high, the resulting bump will disappear in a short time. However, when the reset setting is low, the bump will persist as an offset.

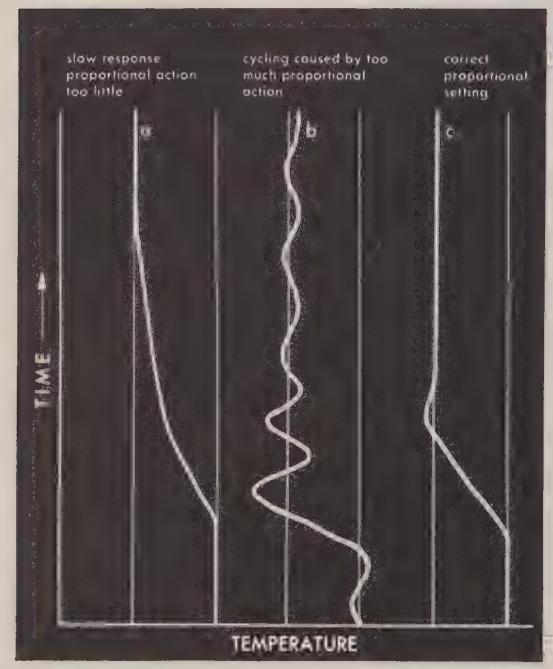
RESPONSE TO PROCESS LOAD



RESPONSE TO PROCESS LOAD



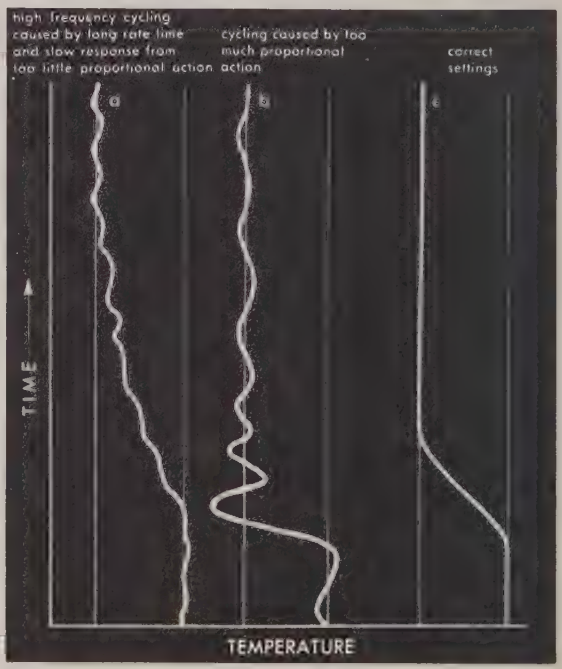
RESPONSE TO SET POINT CHANGE



E5534

Fig. 9(a)-Curves showing the effects of various proportional settings when no reset or rate action is used. Curves c indicate correct setting(s).

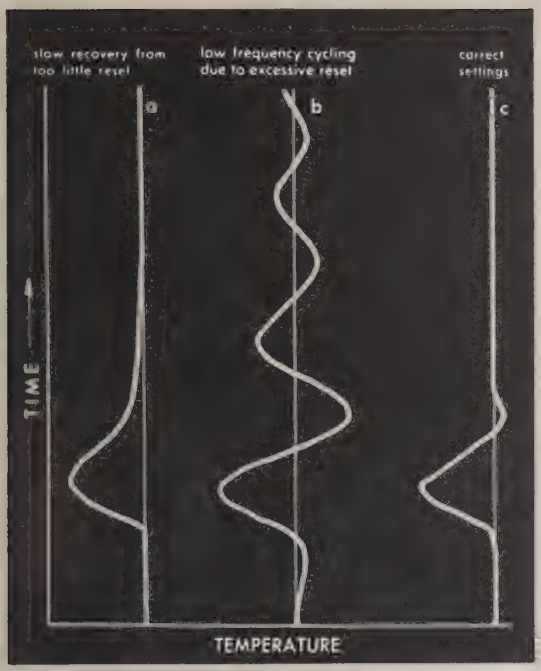
RESPONSE TO SET POINT CHANGE



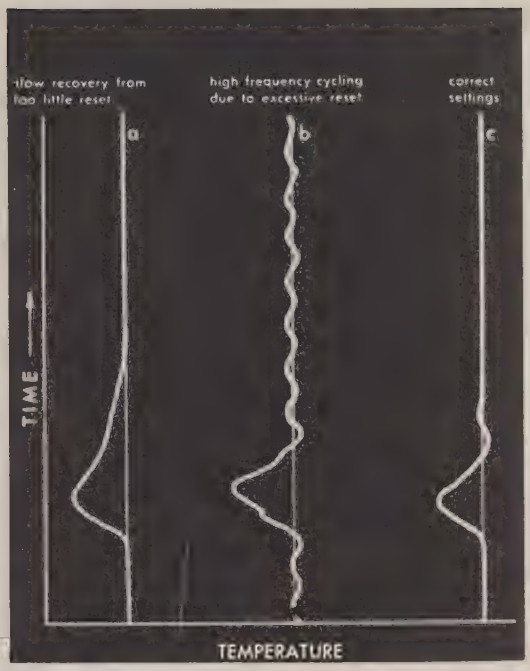
E5535

Fig. 9(b)-Curves showing the effects of various rate and proportional settings with a fixed low value of reset. Note that the higher frequency cycling indicates too much rate while the low frequency cycling indicates too much proportional action.

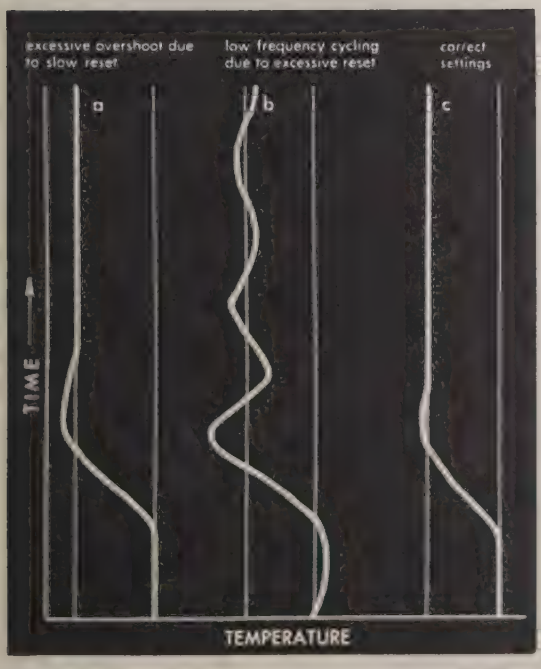
RESPONSE TO PROCESS LOAD



RESPONSE TO PROCESS LOAD



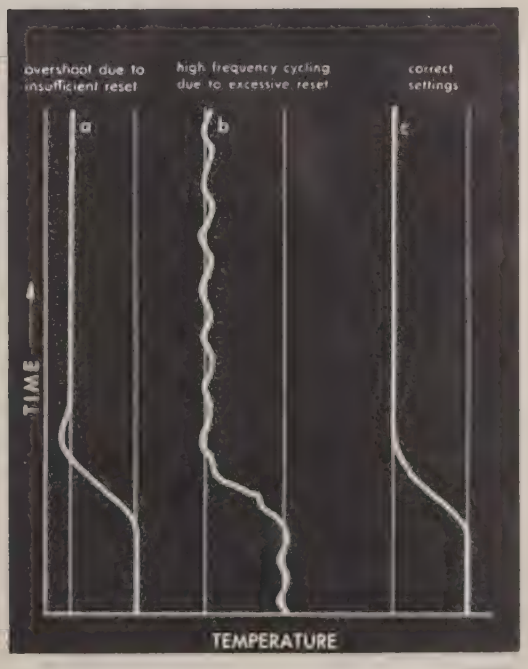
RESPONSE TO SET POINT CHANGE



E5536

Fig. 9(c)–Curves showing the effect of various reset control settings when correct proportional action but no rate action is used. Note that the cycle indicating excessive reset is slow when no rate is used.

RESPONSE TO SET POINT CHANGE



E5537

Fig. 9(d)–Curves showing the effect of various reset control settings when both proportional and rate action are present. Note the higher frequency cycling for excessive reset when rate is used.

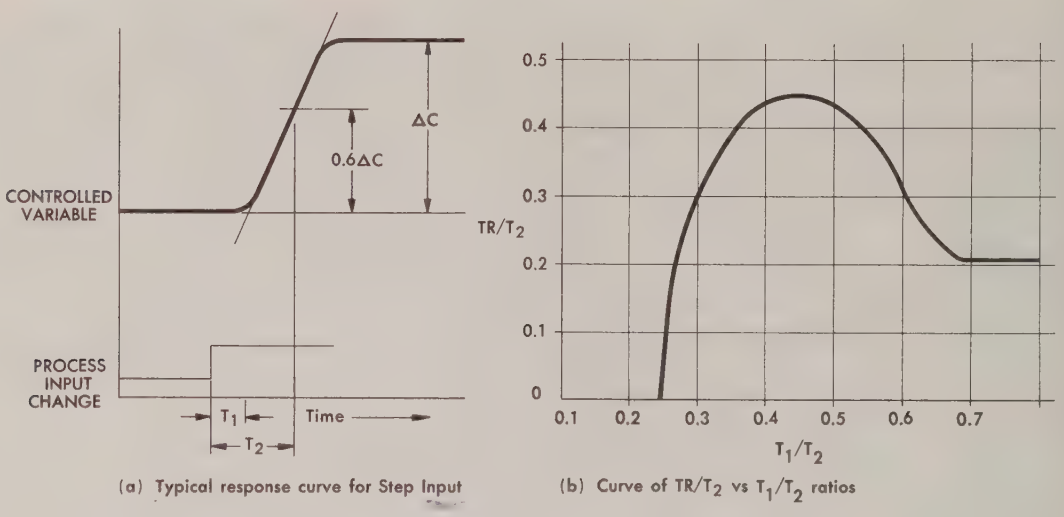


Fig. 10—Curves for obtaining initial rate time, TR.

by too low a Proportional Band setting, the process probably has a short time lag and cannot take rate action. In this case, turn the Rate Time setting to zero.

If the process has appreciable time lag, increase the Rate setting progressively, introducing minor upsets as before, after each increase to show any tendency toward cycling. Once cycling becomes evident, decrease the Rate Time setting until cycling is eliminated.

As rate action is introduced, Proportional Band can normally be decreased in small steps. If cycling occurs, and its frequency is essentially the same as that of proportional band, increase the Proportional Band setting; if it is considerably higher, decrease the Rate Time setting (Fig. 9(b)).

Where instrumentation for a particular process includes several controllers, it is advisable to watch the effects of the rate adjustment on other controlled variables. Rate action augments proportional action, and it is possible that small changes in set point for one variable may adversely affect the stability of overall control. Under these circumstances, the Rate Time setting may have to be decreased substantially, or even reduced to zero.

10C. Inverse Rate (Lag)

As the Lag setting is increased, the rate of change in final control element position decreases for a given controlled variable or set point change.

Lag should only be used where the controlled variable signal is fluctuating rapidly and causes unnecessary control action. Add minimum lag time by turning the Lag knob to 0.2 seconds. Watch the movement of the output meter or of the particular mechanical element for excessive activity. Increase the Lag setting until the control action is reduced to a satisfactory level. Excessive lag time causes the control to deteriorate, so that the Lag setting should be kept as low as possible. As Lag is introduced, the Proportional Band setting can normally be increased until cycling occurs again. However, if the frequency of cycling is appreciably higher than with proportional band alone, the Lag setting can be increased.

Where several controllers are used in a process, note the effects of lag on other controlled variables. Lag slows the control loop proportional response to process disturbances or demand changes, which means that deviations between demand and process persist for the lag period. If the persistance of this error adversely affects other interdependent loops, the lag time may have to be reduced.

10D. Reset

As the Reset setting increases, the integrating action of the final control element increases for a given deviation from set point.

With zero rate action, the Reset setting is too high (Fig. 9(c)) when the system cycles at a lower frequency than that due to a low Proportional Band setting. Under these conditions, the Reset setting should be reduced.

The Reset setting should be systematically increased after the Proportional Band and Rate adjustments have been made as described above. As reset action is introduced, the control record must be carefully observed (Fig. 9(d)).

As reset action is increased, the basic stability of the control action is decreased. In general, the product of the Reset and Rate settings should not exceed 3. For example, if the Rate Time setting is 2, the Reset setting should not exceed 1.5.

10E. Approach (Option)

In the control of a batch-type process, such as a fuel-fired furnace whose temperature must be raised to a specific set point, a final control element such as a fuel-control valve may remain at a limit for an extended period. The feedback circuit is such that no final control element action will take place until the controlled variable returns to set point and starts to deviate in the other direction. Overshoot, of course, would be inevitable. Fig. 11 shows the effects of several Approach settings on the controlled variable.

Introduce approach only after proportional band and reset adjustments have been made. The correct Approach setting is made experimentally.

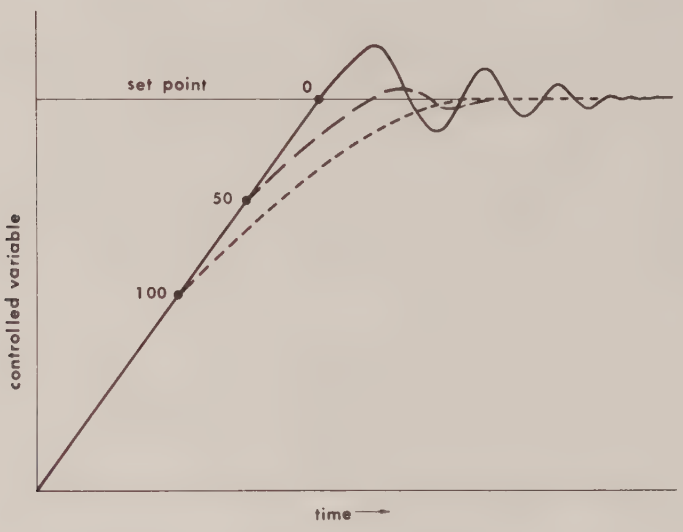


Fig. 11–Effects of Approach setting.

(a) Set Proportional Band at approximately 50, and Reset at 0.05.

(b) Apply input signal and adjust Set Point upscale until the feedback signal at D2 (D7 SC) is at maximum negative voltage level (typically -15 V for P.A.T., -7 V for C.A.T. and -10 V for D.A.T. controller). For reverse-acting control, turn set point downscale.

(c) Set approach control A, behind the sliding door of the front panel*, at 200 (max).

(d) Check for maximum negative voltage at D2.

(e) Adjust approach calibration R2 on approach card (444865) until -2 V (approx.) is obtained between D9 (white lead to approach control) and D7 (SC).

(f) Make a final adjustment to the calibration potentiometer so that the -2 V drops to zero when the negative feedback voltage at D2 is about 95% of maximum (adjust input or set point to change D2 voltage).

The Approach setting determines the controlled variable level at which the initial action takes place. Once the final control element has moved from its fully-on position, approach action stops and the response to the controlled variable depends upon the Proportional Band and Reset settings.

10F. Summary of Tuning Instructions

Adjust Proportional Band to the minimum stable setting.

*On controllers with Option 880, the Approach control is mounted on the support bracket with the nameplate.

Adjust Rate Time to the maximum stable setting.

Adjust Reset to the maximum stable repeats per minute.

Eliminate cycling resulting from an incremental adjustment by reversing the adjustment that causes it.

Compare frequency of cycling resulting from critical adjustment of each of the three actions.

Eliminate or reduce cycling from one or more causes in order of frequency, starting with the highest frequency.

Allow sufficient time after each adjustment for system to stabilize.

If cycling cannot be completely eliminated, tune for minimum frequency and amplitude.

PART IV TECHNICAL INFORMATION

11. OVERALL OPERATION

The controller consists of input and set point circuits, deviation amplifier, control adjustments, control amplifier and an output driver. The driver operates the particular kind of final control element for which it is designed. The final control element in turn varies the process and in certain cases provides the feedback signal to the controller. The deviation alarm is a controller option which controls an audible or visual alarm indicator when the controlled variable deviates from set point beyond the limits set on the deviation alarm. The input/output meter is also an option which, depending upon internal connections, indicates the signal level at the input or output of the controller. See Appendix for schematic diagrams.

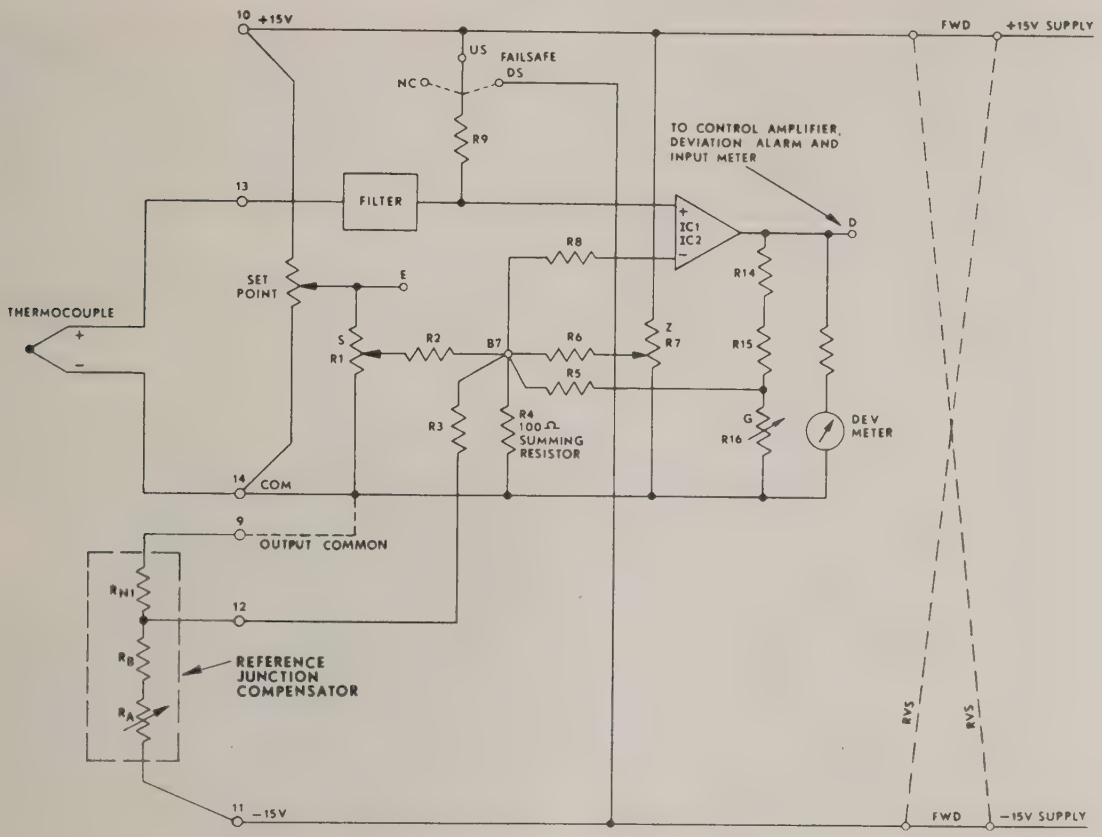
12. INPUT AND SET POINT CIRCUITS

In most applications, the Electromax controller is used to measure and control temperature (low-level input). However, it can also handle the high-level signals from standard transmitters (high-level input). Fig. 12 shows the input and set-point circuits of the Electromax controller with connections for thermocouple and reference junction compensator. The jumpers are in the FWD position for standard (forward-acting) control. To provide reverse-acting control, the jumpers are place in the RVS position which reverses the polarity of the set-point and failsafe voltages and necessitates reversing the thermocouple leads and meter leads.

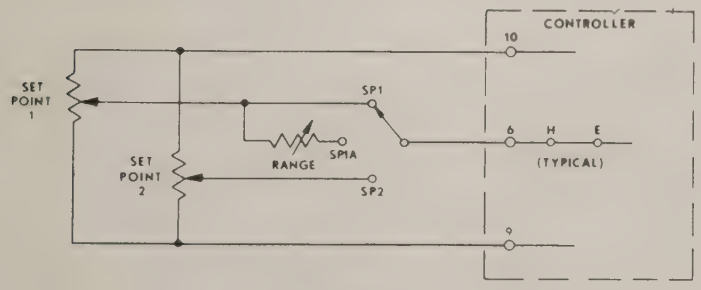
The unique set-point circuit is essentially a current-summing network that develops a reference voltage from a high-level source. The analog or digital setter adjusts the 1000-ohm, set-point potentiometer across the +15-volt source so that the voltage at the potentiometer's arm is essentially proportional to its position. This set-point voltage at jack E is scaled to the desired set-point range by span S potentiometer R1 and converted to a current by R2 to develop a reference voltage across the summing resistor R4 (100 ohms). The current through R4 is limited by the value of R2 (range selection) to 1 mA and proportional to the set-point setting, so that the reference voltage at jack B7 has a range of 0 to 100 mV maximum.

The set-point voltage is normally compared with a positive low-level input voltage at terminal 13 by the differential amplifier IC1 and IC2. When the input voltage is at set point, the differential amplifier output at jack D is zero. However, when the input voltage is above set point, the output voltage is positive, and negative when the input is below set point. Alternatively, a high-level input at terminal 12 (–) can be compared with the set-point voltage at the summing resistor R4.

The high-voltage level at which the set-point potentiometer operates makes it possible to mount the setter remote from the controller and



INPUT AND SET POINT CIRCUITS



REMOTE SETTER SELECTION

AE6150

Fig. 12–Simplified input and set-point circuits of Electromax III controller. Connections of remote set-point setters are shown in lower diagram.

connect the setter leads to controller terminals 7, 9, and 10. The routing or length of the leads is not critical. Attenuation of transverse noise in the front end of the controller is on the order of 50 dB. Where several remote setters are used with one controller, the setter as well as range selection can be made with conventional switch contacts or relays without the usual problems associated with dry circuit configurations. Fig. 12 shows a possible setter selection circuit.

An independent suppression adjustment R7 (Z) provides the low-end setting of the set point by supplying current to the summing resistor R4 via the suppression resistor R6.

12A. Thermocouple Input

Fig.12 also shows typical thermocouple connections to the Electromax controller with a reference junction compensator. The thermocouple is connected to the low-level input 13 (+) and 14 (–) through a filter with a 50 dB attenuation at 60 Hz to the non-inverting input of the deviation amplifier. Reference junction compensation is accomplished by applying a negative bias of approximately 2 volts from the reference junction compensator to the high-level input (12). The reference junction compensator consists of a nickel coil (400 ohms) RN1 in series with resistors RA and RB across the –15-volt power supply. The nickel coil is placed in close proximity to the input terminals which form the reference junction with the extension leads from the thermocouple. As the ambient temperature increases, the resistance of the nickel coil increases and raises the negative voltage drop across the coil. Since the voltage across R4 is the algebraic sum of the current due to the positive set-point voltage and the negative compensator voltage, the R4 drop decreases as the ambient temperature increases, thus compensating for the change in reference junction temperature. The RJ compensator is universal and can be calibrated for any thermocouple. However, it has been factory-set for the range specified.

12B. Failsafe Circuit

The failsafe circuit consists of a high resistance R9 which can be connected to jack US or DS for upscale or downscale operation, respectively. Under normal conditions, the circuit has no effect upon the operation of the controller. However, should the thermocouple circuit open, enough current flows through R9 to drive the differential amplifier output to the high limit (US) or to the low limit (DS). When failsafe action is not required, R9 is plugged into jack NC.

13. DEVIATION AMPLIFIER

The deviation amplifier consists of two dc differential amplifiers in tandem. The non-inverting (+) input of the first stage is connected to the low-input source, such as a thermocouple, or grounded when not used. The inverting (–) input is connected through resistor R8 to the summing resistor R4 to which the set point, high-level input and amplifier output

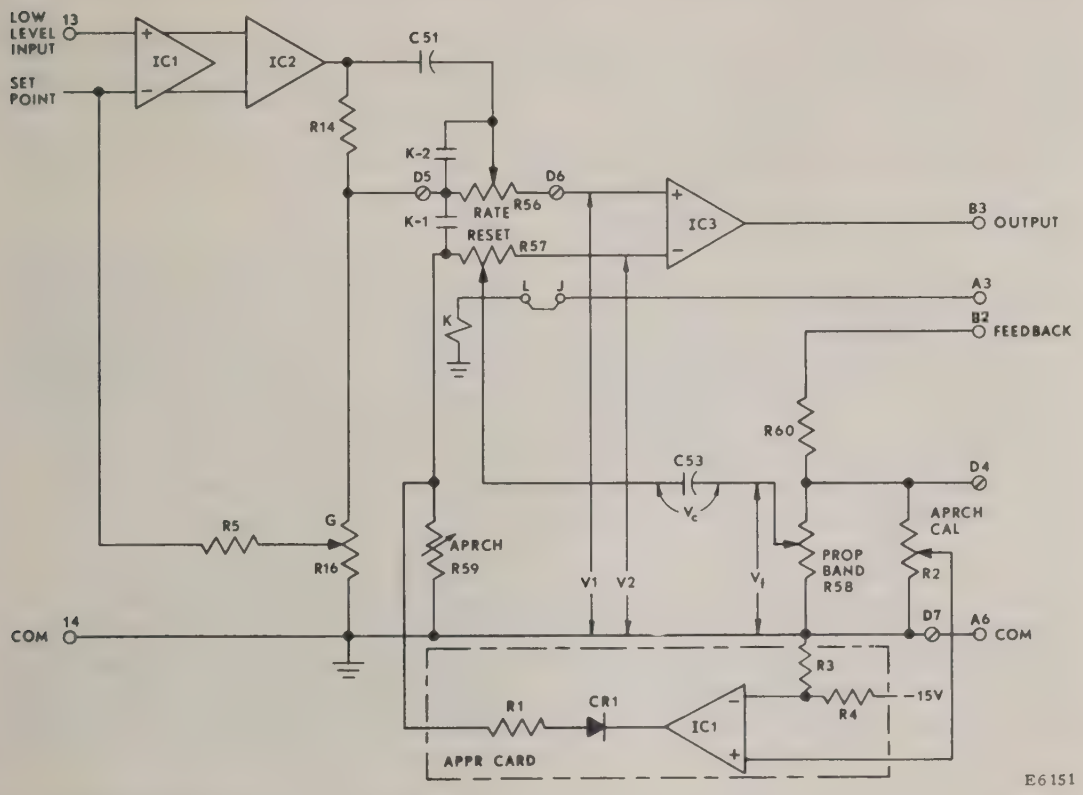


Fig. 13–Deviation amplifier IC1IC2, control adjustments and control amplifier IC3.

are connected through their respective resistors R2, R3 and R5. When a thermocouple is connected to the low-level input, a reference junction compensator card is connected to the high-level input.

The first amplifier has a gain of 100 but has a near-perfect temperature coefficient of drift because of its internal regulating system. This characteristic minimizes the amplifier drift to less than 1 μV per degree. The second amplifier has a gain of 20,000 and the capability of delivering 50 mW to a resistive load. The combined amplifier has an open-loop gain of 2,000,000 which imparts a high degree of stability to the closed-loop circuit. Feedback is provided from the output to the inverting input by the gain adjustment G and R5 to obtain a ±5-volt output corresponding to ±50° of input signal from a suitable sensing device. The amplifier output is indicated by the deviation meter. One or two deviation alarm circuits can be supplied which are operated from the output of the deviation amplifier.

14. CONTROL AMPLIFIER

The output of the deviation amplifier IC1IC2 is applied to the input of the control amplifier IC3, which compares it with a feedback signal. See Fig. 13. Control features modify the control amplifier output to provide

proportional, reset, rate and approach action as specified. The control amplifier output (±10 V dc) is then applied to one of several driver circuits for P.A.T., C.A.T., D.A.T. or other control output.

15. ALARM AND METER CIRCUITS

15A. Deviation Alarm (444866)

The deviation amplifier output E6 is applied to the input of the deviation alarm card, which consists of a differential amplifier IC1, transistor Q1 and relay K1. When the input voltage is within the deviation limits set by R2 and R5, the negative voltage setting of R5 causes diode CR5 to clamp the inverting (-) input of IC1 to signal common and the positive voltage setting of R2 causes diode CR6 to clamp the non-inverting (+) input of IC1 to signal common. Since both inputs are grounded, the output of IC1 is 0, diode CR7 is cut off, transistor Q1 is cut off, relay K1 is de-energized and its contact is open.

As the input voltage becomes more positive, a point will be reached where the inverting input becomes positive when the current due to the positive input voltage is equal to or greater than the current due to the negative voltage of the R5 setting. This causes CR5 to become cut off, consequently the IC1 output becomes negative in proportion, CR7 and Q1 conduct, K1 becomes energized, its contact closes and the red lamp is lit.

As the input voltage becomes more negative, a point will be reached where the non-inverting input becomes negative when the current due to the negative input voltage is equal to or greater than the current due to the positive voltage of the R2 setting. This causes CR6 to become cut off, the IC1 output becomes negative in proportion, CR7 and Q1 conduct, K1 becomes energized and its contact closes.

Resistor R12 and capacitor C1 eliminate chatter in the relay contact.

15B. Input Alarm (444862 and 444866 Cards)

The deviation amplifier output E6 (directly proportional to controller input signal) is reduced to less than 1/10th and applied to E5. The set point voltage is applied to E2 (E7 is common). These two voltages are applied through R2 and R5 to the non-inverting input (3) of IC1 of the input/output card 444862. The amplified output of IC1 at E8 is connected to E6 input on the deviation card 444866, and the operation from this point on is the same as described in Section 15A.

15C. Input Meter

The input meter circuit consists of an input/output card 444862 and an M2 meter as shown in Fig. A3(d) in the appendix. The circuit operates as described in 15B, except that meter M2 replaces the alarm card across the output E8 to indicate the input signal.

15D. Output Meter

The output meter circuit consists of an input/output card 444862 mounted on the D (output) studs and an M3 meter as shown in Fig. A3(c) in the appendix. The card input is connected to the D2 stud so that the meter reads the controller output (except ON-OFF type).

16. OUTPUT DRIVERS

Each output driver is plugged into the A1-A8 and B1-B8 jacks on the controller PC card. The driver input is the ±10 V dc output of the control amplifier B3. The driver output, which depends on the driver type, is connected to the 14-contact connector and terminal board. See Figs. A2(a) to (l).

When a manual station (G3,4,5) is specified, an ATR relay (F2,3,6 or 7) must be specified to obtain bumpless transfer from manual to automatic.

16A. P.A.T. Driver

The P.A.T. driver consists essentially of an operational amplifier IC1, two relays K1 and K2 and two isolated triac circuits (Q1, Q2). Each triac, when conducting, connects one of the windings of a bi-directional motor of a drive unit to the ac line. The slidewire arm of the drive unit is connected to the feedback terminal (8) of the controller.

When the driver input voltage is zero, the IC1 output is zero and neither relay is energized, so that no gate voltage is applied to either triac and neither motor winding is energized.

When the input voltage is positive, the IC1 output is negative, diode CR4 conducts and K2 is energized so that its contact closes. The closed contact applies a gate voltage to triac Q2, which conducts and applies the ac line voltage to the motor winding connected across its output. The triac continues to conduct until the end of the half-cycle of line voltage in which the gate voltage is removed (K2 is de-energized). When the input is negative, IC1 output is positive and Q1 conducts when CR3 conducts and K1 is energized.

The RC networks, R9C2 and R11C3, keep the rate of rise of the voltage across each triac below the triac's dV/dt rating to prevent the triac from conducting without a gate voltage. The thyrector diodes, CR5 and CR6, consisting of two selinium rectifiers back-to-back with Zener diode characteristics, keep the triac voltage below the peak blocking voltage rating.

The G(R62) control is adjusted to the point where the drive unit is on the verge of hunting but has stopped.

When an auto-manual station (G5) is specified and the A (automatic) button is depressed, the driver operates as described above. However,

when the L (lower) button is depressed, a positive voltage is applied to driver input B3 which energizes K2 and causes triac Q2 to conduct until the end of the half-cycle of line voltage in which the L button is released. When the R (raise) button is depressed, a negative voltage is applied to the driver input which energizes K1. This causes triac Q1 to conduct until the end of the half-cycle of line voltage in which the R button is released.

16B. C.A.T. Drivers

The C.A.T. driver varies the dc current through an external resistive load as a function of the control amplifier output voltage B3 and by means of an auxiliary PNP transistor stage, develops a feedback voltage of the opposite polarity to that of the load voltage drop.

(1) Hard C.A.T. (444872)

When the control amplifier output is at −10 V dc, transistor Q2 is cut off. This, in turn, causes Q3 and Q4 to conduct and draw current through the external load and the feedback circuit, respectively. When the control amplifier output is at +10 V dc, transistor Q2 conducts, driving Q3 and Q4 to cutoff and the current through the external load and feedback circuit to zero. The potentiometer R62 is used to adjust for maximum current, by limiting the base signal to Q3.

When an auto-manual station (G3) is specified and the A (automatic) button is depressed, the controller operates as described above. However, when the A button is released by depressing it again, the controller is in the manual mode and the knob (R5) can be rotated to manually adjust the driver input voltage (−15 V to +15 V dc) at B3 to obtain the required output current.

(2) Soft C.A.T. (444857)

The soft C.A.T. controller is normally specified with an auto-manual station (G4). When the A (automatic) button is depressed, relays K1 and K2 are de-energized. With the driver input voltage at B3 at −10 V dc or +10 V dc, both transistors Q1 and Q2 are either cut off or conducting, respectively. The circuitry following Q1 is the same as that of the hard C.A.T. driver and operates as described in the first paragraph of Section 16B (1) above. However, when the R (manual, raise) button is depressed, −30 V dc is applied to A4 which energizes K1 and −15 V dc is applied to A3 which energizes K2 as well as the ATR relay K1 on the main PC card. With K2 energized, the driver input at B3 is disconnected. With K1 energized, the −30 V dc becomes the input voltage and is connected through resistor R3 to the gate of Q1. A capacitor C1 and resistor R4 are connected in series between the gate and common, which causes the gate voltage to slowly (RC=16.4 sec.) increase toward −30 V dc and drives the output current toward zero. If the R button is released, K1 becomes de-energized, thus disconnecting the −30 V from the gate so that C1 (and the gate) is isolated and holds the charge it had developed when it was disconnected. Thus the output current level remains constant until one of the manual or

automatic buttons are again depressed. When the L (manual, lower) button is depressed, +30 V dc is applied to A4 which energizes K1 and −15 V dc is applied to A3 which energizes K2 as well as the ATR relay on the main PC card. The B3 input is again disconnected and the +30 V dc is applied through the RC circuit to the gate of Q1. This causes C1 to become charged positively, so that as the gate of Q1 becomes more positive, the output current increases. If the L button is released, C1 holds its charge as before so that the output current level remains constant, until one of the buttons is again depressed.

16C. ON/OFF Driver

The output of the ON-OFF driver card 444858 is a normally-open, isolated relay contact which only closes when the input is between −0.8 and −10 volts dc. This input voltage reverse biases transistor Q1 (and forward biases Q2), which energizes relay K1, closes its contact, and lights an amber lamp on the front panel. When the input voltage becomes less negative than −0.8 volts, Q2 is cut off, K1 is de-energized and its contact is open.

When suffix J805 is specified, an output triac is operated by relay K1 (445280). The triac conducts (ac supply) when K1 contact is closed, and is cut off when the contact is open.

When suffix H21 is specified, the relay K1 contact is routed to a triac assembly at the rear of the case, which is capable of delivering up to 1 kW of ac power to an external load. Option J805 is not compatible with H21.

16D. P.E.T. Output Driver

When the P.E.T. driver input is zero or positive, the input switch Q1 is conducting, thus preventing the unijunction transistor generator Q2 from oscillating and triggering the triac. Under these conditions, the voltage across the load is zero.

However, when the input is negative enough to drive Q1 to cutoff, capacitor C1 begins to be charged through R4 until its voltage forward biases the unijunction transistor, thus causing C1 to discharge through the UJT to common, until the UJT is cut off and C1 begins to be charged again. The capacitor continues to charge and discharge at approximately 10 kHz until Q1 conducts. Thus the pulse stretcher and booster, Q3-Q6, is pulsed by the oscillator output to provide negative gate pulses to trigger the triac gate. The pulses are shorted by switches Q7 and Q8 except when the line voltage crosses zero between half cycles. This is accomplished by applying the line voltage through two diodes; Zener diodes and resistors to the base of switches Q7 and Q8 so that Q7 and Q8 alternately conduct except when the line voltage is essentially zero (zero voltage switching feature).

On the triac assembly (173072), the triac applies the line voltage to the external load in full cycles. The load voltage, in turn, is half-wave

rectified, and capacitor C1 is charged to form a (+) feedback voltage, which reduces the (−) input voltage at the summing junction (Q_{1b}). This causes Q1 to conduct again, the oscillator to cut off and, consequently, the triac is cut off at the end of the cycle. Since this is no load voltage, the feedback voltage drops off (C1 discharges) until Q1 is cut off and the process is repeated. The resulting load voltage is a series of cycles at line frequency which are switched on and off in such a way that the load power is proportional to the negative input voltage.

When an auto-manual station (G3) is specified and the A (automatic) button is depressed, the controller operates as described above. However, when the A button is released by depressing it again, the controller is in the manual mode and the knob (R5) can be rotated to manually adjust the driver input voltage (−15 V to +15 V dc) at B3 to obtain the required output.

16E. D.A.T. Output Driver

The D.A.T. driver consists essentially of an operational amplifier IC1, emitter followers Q1Q2, an astable multivibrator (Q3 to Q6), a pulse amplifier Q7, a relay (reed switch) K1. The multivibrator provides pulses at a rate of 1 to 10 pulses per minute, as determined by the setting of G (R62).

When the driver input at B3 (A6 is SC) is positive, Q1 and Q2 are cut off so that the supply voltage to the multivibrator is zero and its output is zero. When B3 is negative, Q1 and Q2 become forward biased and a voltage is applied to the emitter of Q3 and Q6. As the input voltage varies from 0 to −10 volts, the voltage at Q3 and Q6 varies but the sum of the emitter voltages equals −10 V at any time. Trimpot R1 is factory-adjusted to make $V_{Q3} = V_{Q6} = -5$ V when the input voltage is −5 volts. The duty cycle of the output waveform increases as the input signal becomes more negative.

For ac or dc loads below 10 watts, driver card 444869 is used, in which relay contact K1-1 is connected directly into the load circuit and an arc suppressor assembly is connected across the contact terminals 4 and 5. An amber panel lamp indicates when the contact is closed.

When suffix J805 is specified, driver card 445279 is used, in which an output triac Q8 is operated by contact K1-1 of the above circuit. The triac conducts when contact K1-1 is closed. (The arc suppressor is not used.)

When suffix H21 is specified, contact K1-1 of driver card 444869 is routed to a triac assembly at the rear of the case, which is capable of delivering up to 1 kW of ac power to an external load. Option J805 is not compatible with H21.

When an auto-manual station (G3) is specified, and the A button is released, the controller is in the manual mode and the knob (R5) can be rotated to manually adjust the driver input voltage for the required load power.

16F. Overheat and Underheat Alarms - 444859

The overheat alarm driver PC card consists essentially of a relay driver Q1 output relay K1 with one set of isolated NO and NC contacts terminated at the case terminal board and another set (NO and NC) to provide one of the six overheat and underheat alarm circuits, jumper positions 1 to 7, jacks for PB1 and PB2 reset switch leads and LT leads for the red panel lamp. A positive voltage at B3 (A6 common) forward biases Q1 which energizes K1. The positions of the jumpers and reset switch connections determine the type of alarm available. See Fig. A2 (h) in the appendix for jumper positions, reset switch and lamp connections, and Section 9F for operating conditions.

17. POWER SUPPLIES

The power supplies consist of two unregulated outputs, −30 V dc and +30 V dc, and two regulated outputs, −15 V dc and +15 V dc. The 30 V outputs are obtained by a bridge rectifier CR1 and filtered by C7 and C10. The 15 V outputs are reduced from the 30 V dc and regulated by control elements Q1 and Q2, and IC regulators IC4 and IC5. Simplified circuits of both are shown in Fig. 14.

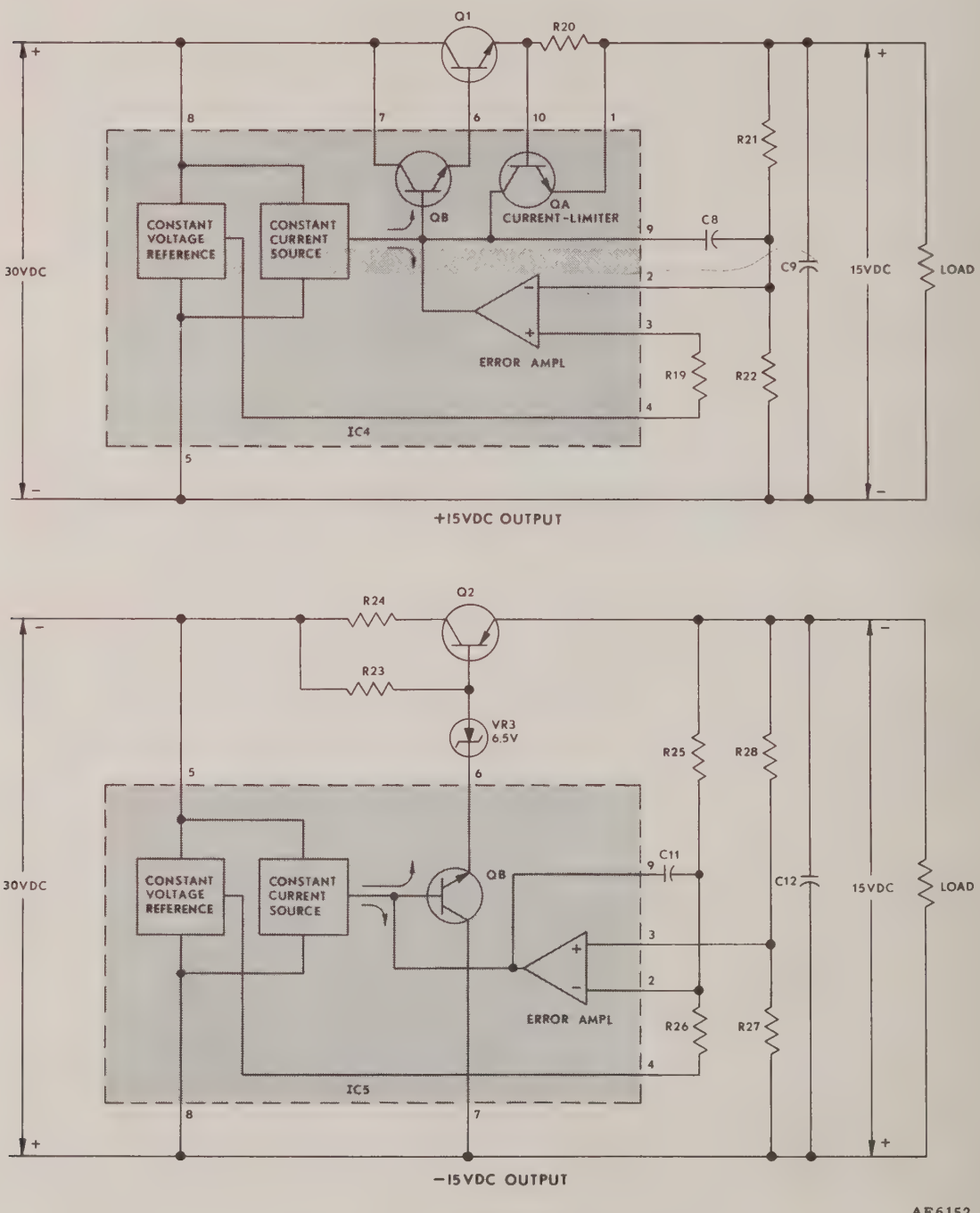


Fig. 14–15 V dc regulated supplies.

PART V SERVICING

NOTE: The schematic diagrams, PC assemblies and parts lists in the Appendix of this book were up-to-date at the last printing, but any revisions made since that time will not appear until the next printing. Therefore, if there is a discrepancy between this information and the drawings and parts list accompanying your instrument, the latter should be considered the most up-to-date.

18. TEST EQUIPMENT

The following items of equipment are required for servicing or calibrating the controller:

- Volt-ohmmeter, such as Simpson Model 260.
- Vacuum Tube Voltmeter. Required primarily for checking the optional approach circuit.
- In-circuit transistor tester to test transistors without removing them from the circuit (MICRONTA 22-024).
- 8686 Portable Millivolt Potentiometer, or an equivalent potentiometer having a range of about 0 to 100 millivolts and an accuracy of at least ±0.05%.
- Card Extender 064219.

19. TROUBLESHOOTING (See Figures in Appendix)

If the fault is traced to the Electromax controller, make sure that the controller is all the way in the case so that the connector engages the contacts of the controller PC card. Check the case terminal board screws for possible loose connections. If applicable, check for open thermocouple (13 and 14) and approximately −2 V dc at reference junction compensator (14+ and 12−). In the case of other input signals, check for loss of signal. If trouble persists, use a spare controller with its compensator (if applicable).

Follow the steps in Table III until the fault is isolated in the defective controller and refer to the section listed for further information. Use card extender to gain access to test points on card when energized. Replace the input source with an adjustable voltage covering the same range. If applicable, set front-panel controls as follows, PB at 50, R and A at 0, and Reset at minimum.

If the fault is traced to one of the option or driver cards, replace the faulty card and recheck the circuit conditions. The faulty card can be repaired, if desired, by following the procedures in Sections 19D and 19E.

TABLE III–ISOLATION OF FAULT

MEASUREMENT	MULTIMETER AT CASE TERMINALS	NORMAL CONDITIONS (Meter Range)	POSSIBLE CAUSE OF FAULT (Fig. 4 shows jack and stud location)
1. Line Voltage	1(Neut) and 2	120 V ac	Check line voltage and external fuses.
2. Power Supply Voltages	14(–) and 10(+)* 14(+) and 11(–)*	15 V dc 15 V dc	Remove controller from case and use an extender card to gain excess to test points on the controller card. Check for 15 V dc between studs E7 (–) and E1 (+), and E7 (+) and E3 (–).* If voltages are zero, remove driver card, check jumpers between FWD or RVS jacks and check for 15 V dc between B8 (–) and B1, and B8 (+) and B4. If still zero, check power supplies, Section 19A.
3. Driver Output Vary input above and below set point. Compare output (or contact closures) with Fig. 2. (a) V.A.T. Controller (b) P.A.T. Controller (c) C.A.T. Controller (d) P.E.T. Controller (e) ON-OFF Controller (f) D.A.T. Controller (g) Overheat Alarm Controller (h) Dev. Alarm Controller	 9 and 7 3 and Neutral 5 and Neutral 9 and 5 5 and 15 4 and Neutral 4 and Neutral 3 and 4 4 and 5 9 and 7	 ±10 V dc 120 V ac 120 V ac 0 to +12 V dc 0 to 120 V ac 120 V ac 120 V ac NC (R x 1) Inf. or 0 NO (R x 1) 0 or Inf. (R x 1) Inf. or 0	If controller meters are not functioning properly, remove controller from case, check for loose connections at studs D1-D7 and E1-E7, replace controller in case and recheck. If output functions normally, check meter circuits. If output does not vary as indicated in Fig. 2 for the particular type, remove the driver card, connect a jumper between jacks F and G, (and between terminals 7 and 8 when proportional band is specified) measure output between terminals 9 (–) and 7 (–14 V dc max.) when input has been decreased until Dev. meter reads –50 (D7 to E6 is –5 V dc) and D7 (–) to D5 voltage is –0.5 volts dc.** If the output at terminal 7 has decreased from 0 to –14 V max., the driver card should be replaced.
4. Control Amplifier Output			If the output at terminal 7 did not change from 0 to –14 V max., but the D5 voltage is –0.5 V dc, the fault is in the control amplifier or the calibration settings have been disturbed. See Section 19B for amplifier checks and Section 21B for calibration procedure.
5. Deviation Amplifier Output			If the deviation meter does not read –50 or the D7-E6 voltage does not read –5 V dc, the fault is in the deviation amplifier or the calibration has been disturbed. See Section 21A for calibration procedure or Section 19C for deviation amplifier checks.

* Polarities with standard control; polarities are reversed with reverse-acting control.
** If the reset option is on the controller, it may be necessary to place reset at about 5 Rep/Min in order to get control action near set point.

Normal voltage conditions are shown in the following subsections and the possible faulty component(s) when they are not obtained.

19A. Power Supplies

With line voltage applied to the controller, measure 120 V ac across

KW at J1 and J2, 46 V ac across NN points of rectifier CR1, 60 V dc across ± points of CR1 and 30 V dc across ± points of capacitors C7 and C10. If the 120 V ac is present the fault could be with transformer T1, CR1, C7, or C10 when one of the other voltages is not correct. If these voltages are normal, check the following voltage points:

A6 (–) to $IC4_6$	15.5 V dc
A6 (–) to R20 (bottom lead)	15 V dc
A6 (+) to VR3 (bottom lead)	15.5 V dc
Across VR3	6.2 V dc

Also check for overloaded conditions. The voltage drop across R24 should not exceed 10 V (–15 V supply) and the drop across R20 should not exceed 0.6 V (+15 V supply). A defective driver could overload the –15 V supply.

If any of these voltages is off by ±20%, remove the power from the controller and measure the resistance values of R19 to R28 against parts list in Fig. A1(a), low resistances across C9 and C12 (< 1K) and forward/reverse resistances of VR3. If an in-circuit transistor tester is available, check Q1 (NPN) and Q2 (PNP) for operative condition. Replace any faulty component and recheck controller operation. If there are no faulty components found, the fault is in integrated circuit IC4 (+15 V) or IC5 (–15 V) and it is recommended that the controller be returned to L&N for repair.

19B. Control Amplifier Section

Remove power from controller and check resistance values of resistors between D5 and D6 and between inverting (–) input (terminal 2) of IC3 and signal common, D7. If both resistances are 1 meg ±20%, short D5 to D7 and short reset capacitor (option) with temporary jumpers. Set PB control at 20° and turn power on. Controller output should be approximately zero. Vary controller Zero, behind the front-panel door, to see if the output changes. Check voltage between IC3 terminals 2 and 3 (10 mV max). If not, IC3 is defective and should be replaced. It is recommended that the controller PC card be returned to L&N for repair.

19C. Deviation Amplifier

Observe set-point voltage, E7 to E2, as setter is varied. It should change smoothly between 0 and 15 V dc. If 0 V, check setter pot resistance and connections. The deviation amplifier output, E7 to E6, should also change. If not, remove the thermocouple or jumper between terminals 13 and 14. With failsafe resistor R9 in jack US or DS the output voltage, E7 (–) to E6, should change to +10 V or –10 V, respectively. If not, remove the controller and check the resistances of R1 to R16 and R18. If one of the resistors is faulty, replace it and recheck deviation amplifier performance. If resistances are within ±20%, as measured by

the multimeter, the fault is in the deviation amplifier IC1 or IC2 and should be returned to L&N Company for repair. However, if replacement of IC1 or IC2 is attempted, replace the less expensive IC2 first and recheck operation. After replacement of IC1 and/or IC2, calibration procedure of Section 21 must be followed.

19D. Option Cards

The schematic diagrams and PC card layouts are shown in Fig. A3(a) - (d). See Fig. 4 for location of studs. Check the supply voltages at the option card (D & E) studs; as follows:

TEST POINTS*	VOLTAGE
D7-D1	+15 V dc (±1 V)
D7-D3	-15 V dc (±1 V)
E7-E1**	+15 V dc (±1 V)
E7-E3**	-15 V dc (±1 V)

*D7 and E7 are the signal common of the option cards.
**Polarities are reversed for reverse control action connections.

(1) Deviation Alarm Card (444866)

As the input voltage (E7E6) is varied from 0 to beyond the limits set by R2 (B) and R5 (A), make the following voltage checks in sequence:

TEST POINTS INPUT E7 TO E6	NORMAL VOLTAGES			POSSIBLE FAULTY COMPONENTS
	0 V	-10V	+10V	
E7 to $IC1_4$	-14.5V*			CR3,CR4
E7 to IC17	+14.5V*			CR1,CR2
E7 to CR7 & IC16	0	-12V	-12V	CR5,CR6,R2-R5,R7-R10,C2&IC1
E7 to CR7 & R12	0	-11.5V	-11.5V	CR7
E7 to Q1b	0	- 0.8V	- 0.8V	R12,R13,C1
E7 to Q1c	-30V	- 0.5V	- 0.5V	K1 & Q1

*No change with input change.

If the voltages do not agree within ±10%, remove the card and replace it, or check the value of each component in the last column to isolate the faulty component.

(2) Input/Output Card (444862)

With power applied, check for +5 V dc output at E8 or D8 (E7 or D7 common) with standard control action when full range input signal is applied. The output voltage should be −5 V dc with reverse control

action. If output voltage is correct, the card is alright but check the input/output meter by temporarily removing one of its leads from E8 or D8 and connect an ohmmeter with a 10,000-ohm range across the meter to obtain a deflection if applicable. If the voltage is incorrect, replace or recalibrate (Section 21L) the I/O card. To troubleshoot the I/O card, check the resistance values of R1-R5 and the forward-reverse resistances of CR1 to CR4, VR1 and VR2. Replace the faulty component as per Section 20.

(3) Approach Card (444865)

When the output of the controller is maximum (-2 V dc at D4), the output at D9 on the approach card should be -2 V dc (±0.2 V). This latter voltage should drop to zero when the controller output is reduced by 5% (below max.). Adjust App. Cal. (R2) to obtain this condition. If not, remove power from controller and check R1 to R5, R59, CR1 and C1. If these components are normal, the fault is in the IC1 on the approach card.

19E. Driver Cards (See Figs. A2(a)-A2(l))

Before removing the driver card from the main PC card, check the applicable supply voltages* as follows:

DRIVER CARD		VOLTAGES (A6 IS COMMON)			
L&N NO.	TYPE	A1 Jack	B1	A2	B4
444857	Soft C.A.T.	+30 V	+15 V	-30 V	-15 V
444858*	ON-OFF	+30 V	+15 V		
444859	Overheat	+30 V	+15 V		
444869**	D.A.T.		+15 V	-30 V	-15 V
444870	P.A.T.		+15 V		-15 V
444871	P.E.T.	+30 V	+15 V		
444872	Hard C.A.T.	+30 V	+15 V	-30 V	-15 V

*445280 when J805 is specified.
**444279 when J805 is specified.

If a manual station is included in the controllers, press the raise (R) and lower(L) pushbuttons on the front panel to check the voltages as shown below:

MANUAL STATION	TEST POINTS A6 (-)	PRESS BUTTON	VOLTAGE	POSSIBLE FAULTY SWITCH ASSEMBLY
P.A.T.	A6 to B3	R	-10V	444969
		L	+10V	
C.A.T. (Soft)	A6 to A4	R	-30V	
		L	+30V	444968
	A6 to A3	R	-15V	
		L	+15V	
C.A.T. (Hard)	A6 to B3	Rotate R5 knob	-15(CW) to +15V(CCW)	444967

*All voltages are present but not required for each driver.

With the controller input voltage applied, measure the appropriate voltage as shown in the following sub-sections. Each table indicates possible faulty components where the correct voltage or change does not occur. Where several components are listed, the fault can be isolated by component value measurement; try the most simple ones first (i.e., resistance value of resistors, forward-reverse resistances of diodes, etc.). Remove the driver card before making these measurements. Replace the faulty component as directed in Section 20 in this book. Refer to the Appendix for the appropriate driver circuit, component location and parts list.

(1) P.A.T. Driver Card (444870)

Adjust the input voltage to each of the following conditions (or press the R(−) and L(+) buttons) and make measurements in sequence:

TEST POINTS* INPUT VOLTAGE A6 TO B3	NORMAL VOLTAGE			POSSIBLE FAULTY COMPONENT
	0 V	−10 V (R)	+10 V (L)	
A6 to CR3CR4 Junction	0	+10 to +14 V	−10 to −14 V	R1-R6, R62, CR1, CR2, C1 or IC1
A6 to CR3K1 Junction	0	+10 to +14 V	0	CR3
A6 to CR4K2 Junction	0	0	−10 to −14 V	CR4
$Q1_1$ to K1R7 Junction	0	120 V ac	0	K1
$Q2_1$ to K2R10 Junction	0	0	120 V ac	K2
$Q1_1$ to $Q1_2$	0	3 V ac	0	R7, Q1
$Q2_1$ to $Q2_2$	0	0	3 V ac	R10, Q2
$Q1_1$ to $Q1_3$ or A4 to A5	120 V ac	0	120 V ac	R9, L1, C2, CR5, Q1
$Q2_1$ to $Q2_3$ or A3 to A4	120 V ac	120 V ac	0	R11, L2, C3, CR6, Q2

*A6 is dc common.

If a low resistance exists between A4 and A5 or A3 and A4 of Q1 or Q2, unsolder the long lead of CR5 or CR6 to measure the resistances of $Q1_{1-3}$ and CR5, or $Q2_{1-3}$ and CR6 separately. A low resistance indicates a shorted component, which should be replaced.

(2) C.A.T. Driver Cards (444857 and 444872)

As the driver input voltage is varied, (or the manual station buttons are pressed and R5 rotated), check for the following changes:

TEST POINTS* INPUT VOLTAGE A6 to B3	VOLTAGE (V dc)		POSSIBLE FAULTY COMPONENT
	−10	+10	
A6 to $Q1_s$**	− 5	+ 5	R1, R6, Q1
A6(−) to $Q2_c$	0	− 5	R7-R10, Q2
A6(−) to $Q3_c$	+12	+22	R12-R16, R19, R62, Q3, Ext. Load
A6(+) to $Q4_e$	− 6	− 2	R17, R18, Q4
A6(−) to A5	0	+10	Q3

*A6 is dc common.
**Soft C.A.T. driver only.

In the soft C.A.T. driver, check for 4 V ± 0.5 V dc across resistors R2 and R5 when pushbutton R or L is pressed. Zero volts across R2 indicates that R2 or K1 relay coil is open. Zero volts across R5 indicates that R5 or R2 relay coil is open. If both voltages are present, check contacts of K1 and K2 in energized and de-energized conditions. Also check condition of R3, R4, C1, VR3 and VR4.

(3) ON-OFF DRIVER CARDS

Vary the controller input around set point to energize and de-energize relay K1 on the driver card to apply and remove the voltage across the load, respectively. If both conditions can not be met, follow the applicable procedure(s) below.

(a) 444858 Driver Card and 173071 Triac Assembly

Remove controller from case. (Do not remove ac line voltage from load circuit.)

If load voltage is present, replace triac assembly (shorted triac).

Place jumper between terminals 4 and 5. If there is no voltage across the load, replace triac assembly (open triac). Remove jumper.

If neither condition occurs, check (b) for faulty driver card (444858).

(b) 444858 and 445280 Driver Cards

Both cards are the same except that 445280 card has a triac Q3 driven by relay K1. Vary controller input around set point and check for the following conditions:

TEST POINTS* A6 to B3 (INPUT)	VOLTAGE CHANGE		POSSIBLE FAULTY COMPONENT
	0 to −10 V dc	0 to +10 V dc	
A6(−) to $Q1_c$	Increases	Decreases	R1-R6,C1,Q1
A6(−) to $Q2_c$	Decreases	Increases	K1,R7,CR2,Q2
K1 Contacts (End connections) 445280 Only	0	10 kΩ+**	K1,R9
Terminals 4 & 5	0	Supply Voltage	444858 only - K1 445280 only - C3,R9, R10,Q3.

*A6 is signal common.
**Remove controller from case to remove voltages from controller.

(4) Overheat Alarm Driver Card (444859)

Vary the driver input voltage (A6-B3) so that relay K1 becomes energized and de-energized. Press the reset button on the front panel,

if applicable. If both conditions can not be obtained, remove the driver card and replace, or check the resistance values of R1, R2, R4 to R7. Also check the relay coil and contacts, C1 and forward and reverse resistances of CR1 and CR2.

(5) D.A.T. Driver Cards

Vary the controller input around set point to energize and de-energize relay K1 on the driver card to apply and remove the voltage across the load, respectively. If both conditions can not be met, follow the applicable procedure(s) below.

(a) 444869 Driver Card and 173071 Triac Assembly

Remove controller from case. (Do not remove ac line voltage from load circuit.)

If load voltage is present, replace triac assembly (shorted triac).

Place jumper between terminals 4 and 5. If there is no voltage across the load, replace triac assembly (open triac). Remove jumper.

If neither condition occurs, check (b) for faulty driver card (444869).

(b) 444869 and 445279 Driver Cards

Both cards are the same except that 445279 card has a triac Q8 driven by relay K1. Vary controller input around set point and check for the following conditions:

TEST POINTS* A6 to B3 (INPUT)	VOLTAGES 0	-5	-10	+10 V dc	POSSIBLE FAULTY COMPONENT
$IC1_6$	-10		0	-12 V	R2, R4, R1, IC1
$Q1_e$	-9.5	-5	0.5	0	R3, R5, Q1
$Q2_e$	0.5		-9.5	0	R6, Q2, CR2, R16
R6, R7 and R8	-0.5-1		-0.5-1	-0.5-1	R7-R11, CR3, Q3-Q5, C1 and C2.
$Q6_c$	0	-5	-10	0	R12, Q6, CR4
$Q7_c$	-30		0	-30	R13-R15, R17, CR1, R light, K1, Q7.
K1 Contacts (End connections) 445279 Only			0	10kΩ+**	K1, R18.
Terminals 4 & 5			0	Supply Voltage	444869 only - K1 445279 only - C3, R18, R19, Q8.

*A6 is signal common.
**Remove controller from case to remove voltages from controller.

(6) P.E.T. Driver Card (444871) & Triac Assembly (173072)

Turn off the line voltage, adjust the driver input (A6B3) as indicated below, and check the test points for the voltages shown with a Simpson 260 or equivalent. If an oscilloscope is available and no voltages are listed, check the components in the right-hand column.

TEST POINTS (A6-common) B3 (input)	VOLTAGE CHANGE & WAVEFORM -8 V dc	Fig. No.	+8 V dc	POSSIBLE FAULTY COMPONENT
$Q1_c$	-8 V dc		0	R1-R4,CR1,R17,Q1
$Q2_2$	0.35 V dc	15(1)	0.25 V dc	R5-R7,C1,Q2
$Q3_c$	5 V dc		9 V dc	R8,R10,Q3
$Q4_c$	3 V dc	15(2)	0	R9,R11,C2,Q4
$Q5_e$	3 V dc		0	R12,Q5
$Q6_e$	2.5 V dc		0	CR2,C3,R13,T1,Q6
B2	+10 V dc		0	C1,R1,CR1,T1 on triac assembly
(A3-common) $T1_4$		15(3)	0	T1**
$Q8_c$		15(4)	0	R14-R16,CR3-CR7,VR1,VR2, Q7,Q8,T1.
Term.5 & 15*	120 V ac	15(5)	0	Triac**
A3 and A4*			0	Triac**

*Line voltage applied.
**If T1 or triac is faulty, replace 173072 triac assembly.

20. REPLACING DEFECTIVE PARTS

Whenever a defective part has been located on the printed circuit assembly, it can be removed by unsoldering it from the foil side of the card with a small-tip, low-wattage soldering iron. Unsolder it as quickly as possible to prevent heat from loosening the copper foil, and make sure that solder does not obstruct the mounting holes for the replacement part. Transistors and other components can be easily removed by placing the soldering iron on each lead connection and removing the excess molten solder from around the lead by means of a suction bulb with a Teflon tube (Little Joe Excess Solder Remover, SR-25, Mills Equipment Co.). Insert the leads of the replacement part through the holes and bend them slightly on the foil side; cut off the excess wire, and solder the part in place. Before replacing transistors make sure that the projections on the insulator, which separates the transistor from the printed-circuit card. The soldered joints should not be more than 1/16 inch above the card surface.

21. CALIBRATION

Care must be taken to avoid excess noise pickup when the controller is out of the case.

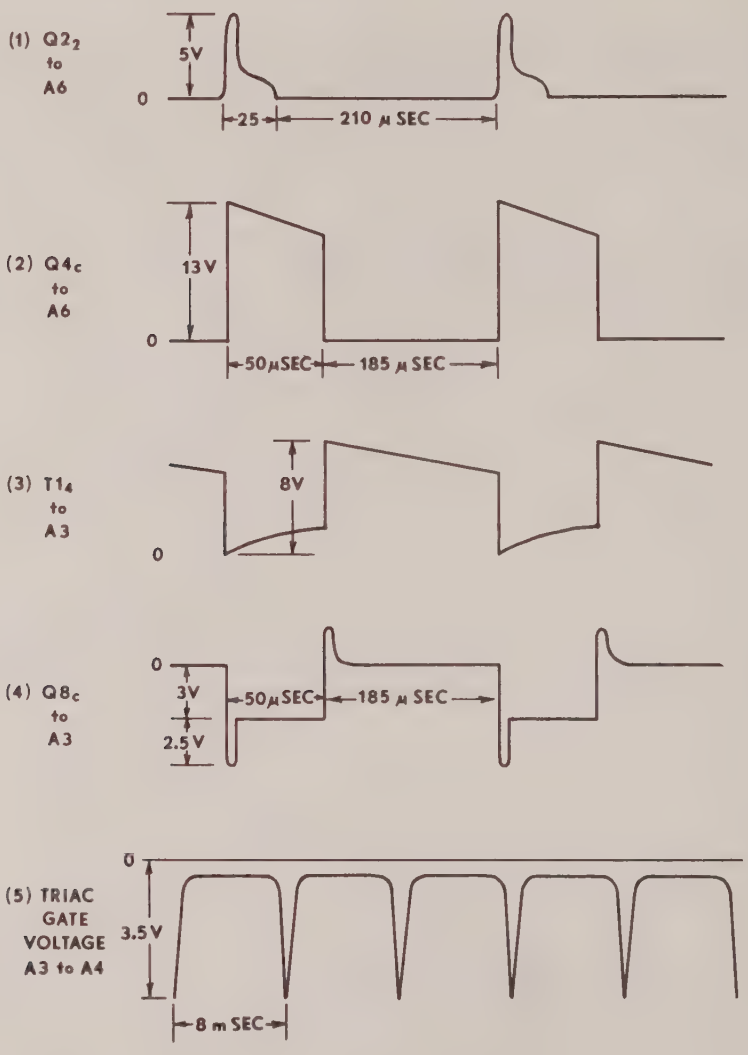


Fig. 15–P.E.T. Driver (444871) waveforms.
(waveforms 1-4; line voltage disconnected)
(waveform 5; line voltage connected)

Normally, the factory calibration settings of Z, S and G on the controller PC card 444861 and Z behind the front-panel door require no adjustment unless the range has been changed or the settings have been disturbed. NOTE: Range changes require different zero, range, gain and linearity resistors (Table AIV).

When calibration becomes necessary, follow the steps below.

CAUTION: Table IV contains calibration data on all the standard input ranges. Every effort has been made to keep it up to date. However, if this information differs from the calibration data supplied with your instrument, use the latter.

21A. Preliminary

(1) Withdraw instrument from case and check zero setting of meters. Adjust mechanical zero as required for center scale readings when no power is applied.

(2) Compensator card (if used)*: Make sure resistor is inserted for proper thermocouple (unplug compensator for this check). See Table V.

(3) Disconnect lug 13 (next to top position) on the card extender, and connect potentiometer to terminals 13 and 14, observing specified polarity of the instrument input.

(4) Insert card extender into case until it fully seats in the 14-point case receptacle. Insert Electromax controller into card extender, making sure that it is also fully seated. Check to make sure that instrument is powered with 120 V ac via panel wiring.

21B. Compensator Calibration (Required Only on Thermocouple Type Inputs)

(1) Put thermometer near compensator card for ambient temperature reading.

(2) With Simpson on the 2.5 or 10 V dc range, connect it to TPA and TPB on the compensator card (rear of case: at top). Polarize connections as required. TPA is common.

(3) Using small screwdriver, adjust compensator voltage for value indicated in Table V. (R5 Adj. - accessible from rear of case - on compensator card.)

NOTE: These voltages have been factory-calibrated at an ambient temperature of 75°F, but may shift as much as ±5% due to ambient temperature changes without affecting the calibration. However, if the setting (R5 on RJ Comp) is changed, the controller must be recalibrated. For greater accuracy when the ambient temperature is more than 5°F from the ambient temperature at which the controller was last calibrated, a calibration adjustment of 3% per 10°F (up or down) can be made.

*Compensator card not used with Type B thermocouples.

TABLE IV–CALIBRATION DATA

Cat. Suffix	TYPE OF INPUT				OVERALL RANGE	INPUT SIGNALS		LOW CAL. PT.		HIGH CAL. PT.	
	EMF	TC*	Therm-ohm	Other		Low End mV	High End mV	mV	Counter /Scale	mV	Counter/ Scale
4001	X				0-10 mV	0	10	0.00	0000	10.00	1000
4002	X				0-20 mV	0	20	0.00	0000	20.00	2000
4003	X				0-100 mV	0	100	0.00	0000	100.00	(1)0000
4004		S			1000-3000°F	3.65	17.70	10.67	2000	14.69	2600
4005		S			500-1500°C	3.34	15.83	9.58	1000	13.15	1300
4006		S			1000-3000°F	4.12	17.23	6.91	1400	10.67	2000
4007		S			500-1500°C	3.82	15.35	6.27	700	9.58	1000
4008		R			1000-3000°F	3.62	19.90	11.76	2000	16.41	2600
4009		R			500-1500°C	3.30	17.71	10.50	1000	14.62	1300
4010		R			1000-3000°F	4.27	19.24	7.46	1400	11.76	2000
4011		R			500-1500°C	3.95	17.06	6.74	700	10.50	1000
4012		J			0-2000°F	-4.11	64.15	17.19	600	42.92	1400
4013		J			0-1000°C	-4.27	59.05	27.39	500	45.50	800
4014		J			0-2000°F	-2.98	62.75	11.02	400	36.00	1200
4015		J			0-1000°C	-1.73	57.00	10.78	200	33.10	600
4016		K			500-2500°F	10.38	56.90	29.31	1300	46.94	2100
4017		K			300-1300°C	11.57	54.49	27.02	650	43.20	1050
4018		K			0-2000°F	-1.90	46.53	7.21	350	36.17	1600
4019		K			0-1000°C	-1.21	42.67	8.14	200	33.28	800
4020		T			0-1000°F	-2.30	27.13	3.97	200	11.03	450
4021		T			0-500°C	-2.11	26.13	6.70	150	12.01	250
4022		WRE			300-2300°C	6.91	39.62	21.72	1200	30.23	1750
4023		J			500-1500°F	12.96	46.51	21.78	750	37.69	1250
4024		K			1000-2000°F	21.92	45.65	26.98	1200	40.58	1800
4026			Pt		-300 to 100°F	23.98Ω	116.88Ω	39.22Ω	-240	101.74Ω	+40
4027			Pt		-100 to 300°F	69.61Ω	158.94Ω	84.26Ω	-40	144.38Ω	+240
4028			Pt		-300 to 300°F	23.72Ω	161.15Ω	52.99Ω	-180	131.74Ω	+180
4029			Ni		-50 to 250°F	74.91Ω	138.86Ω	94.86Ω	+40	122.04Ω	+175
4030					0 to 1000 Units	Uncalibrated					
4031					0 to 2000 Units	Uncalibrated					
4032					0 to 5000 Units	Uncalibrated					
4033					0 to 10,000 Units	Uncalibrated					

*Data based upon IPTS-68 for types B, K, J, R, S, and T thermocouples.
Data based upon Hoskins curve for suffix 4145.
Data based upon G.E. for suffixes 4131-33.
Data based upon Engelhard for suffixes 4022, 4060, 4061, 4065, 4115, 4127 and 4140.

TABLE IV–CALIBRATION DATA (Continued)

Cat. Suffix	TYPE OF INPUT				OVERALL RANGE	INPUT SIGNALS		LOW CAL. PT.		HIGH CAL. PT.	
	EMF	TC*	Therm-ohm	Other		Low End mV	High End mV	mV	Counter /Scale	mV	Counter /Scale
4034		J			0-500°F	-1.41	14.33	1.94	100	12.57	450
4035			Cu		0-100°C	8.96Ω	12.97Ω	9.62Ω	15	12.32Ω	85
4036		S			0-2000°C	-2.08	21.58	4.73	550	11.95	1200
4037		K			200-2200°F	2.65	50.90	10.56	500	40.58	1800
4040		T			-200 to 300°C	-10.64	14.71	2.04	50	9.29	200
4041		J			0-1000°F	-2.03	30.09	6.42	250	24.85	850
4042		T			-100 to 400°F	-3.99	9.54	1.52	100	6.65	300
4043				X	200-1200 2-12 pH (1-5 V)	- .92	-5.08	-1.60	3.50	-4.40	10.50
4044		J			0-200°C	-0.36	10.99	2.06	40	8.56	160
4045		J			0-500°F	-1.10	13.35	0.51	50	3.41	150
4046	X				0-10,000 -5 to +5 mV	-5.21	5.20	-3.50	1500	3.50	8500
4048	X				0.488-10.488 mV	0.49	10.49	1.99	1.988	8.99	8.988
4049		J			-100 to 400°F	-4.36	11.23	-0.51	50	9.48	350
4050		J			0-600°F	-1.55	17.59	2.53	120	13.49	480
4051		K			400-1400°F	7.60	32.25	12.85	600	26.98	1200
4052		K			200-1200°F	3.13	27.46	8.31	400	22.25	1000
4053		K			0-1000°F	-1.28	22.64	3.82	200	17.52	800
4055		T			0-200°C	-0.39	9.00	1.61	40	4.75	110
4056		K			0 to 1400°C	-1.53	59.84	8.54	210	32.04	770
4057				X	-0.5 to +0.5"H_2O	0.08	-4.00	-0.60	-0.350	-3.40	+0.350
4059		S			400-2400°F	0.62	13.41	4.61	1000	10.67	2000
4060		WRE			400-1400°C	6.34	25.91	10.51	600	21.72	1200
4061		WRE			300-2300°C	4.50	42.03	14.37	800	25.03	1400
4064				X	0-10 V	0.21	-10.20	-1.50	1.50	-8.50	8.50
4065		Pl.II			100-1100°C	1.51	47.42	11.28	300	37.59	900
4069		S			500-1500°C	3.52	15.78	7.34	800	13.15	1300
4070	X				0-50 mV	0.00	50.00	00.00	0000	50.00	5000
4071		J			0-1000°F	-1.57	30.06	1.94	100	17.19	600
4072		J			0-1000°F	-1.33	29.89	17.19	600	26.40	900
4078		J			0 to 500°F	-1.18	14.02	0.51	50	6.42	250
4079	X				0 to 18 mV	0.00	18.00	0.00	0000	18.00	1800
4080	X				0 to 10 mV	0.00	10.00	0.00	0000	10.00	5000

*Data based upon IPTS-68 for types B,K,J,R,S, and T thermocouples.
Data based upon Hoskins curve for suffix 4145.
Data based upon G.E. for suffixes 4131-33.
Data based upon Engelhard for suffixes 4022, 4060, 4061, 4065, 4115, 4127 and 4140.

TABLE IV–CALIBRATION DATA (Continued)

Cat. Suffix	TYPE OF INPUT				OVERALL RANGE	INPUT SIGNALS		LOW CAL. PT.		HIGH CAL. PT.	
	EMF	TC*	Therm-ohm	Other		Low End mV	High End mV	mV	Counter /Scale	mV	Counter /Scale
4081		K			0-2000°C	-1.64	82.79	12.21	300	52.40	1300
4082		S			0-2000°C	-2.57	22.00	6.27	700	13.15	1300
4083		J			0-500°C	-0.83	27.82	5.27	100	24.61	450
4084		S			500-2500°F	0.94	14.08	8.13	1600	13.34	2400
4089		S			±50 at 1000°C			-0.58	-50	+0.58	+50
4090					-100 to +100°C	-1.15	+1.15	-1.15	-100	+1.15	+100
4093		S			300 to 1300°C	1.54	13.24	5.75	650	10.17	1050
4095		K			1200 to 2200°F	26.68	49.80	30.48	1350	44.86	2000
4096		T			0 to 500°F	-1.77	12.60	2.71	150	9.52	400
4100				X	0 to 4 V(100 units)	00.00	-4000	-600	150	-3400	850
4101				X	0 to 4 V(200 units)	00.00	-4000	-600	300	-3400	1700
4102				X	0 to 4 V(500 units)	00.00	-4000	-600	750	-3400	4250
4103				X	0 to 4 V(1000 units)	00.00	-4000	-600	1500	-3400	8500
4105				X	1 to 5 V(100 units)	-1000	-5000	-1600	150	-4400	850
4106				X	1 to 5 V(200 units)	-1000	-5000	-1600	300	-4400	1700
4107				X	1 to 5 V(500 units)	-1000	-5000	-1600	750	-4400	4250
4108				X	1 to 5 V(1000 units)	-1000	-5000	-1600	1500	-4400	8500
4110				X	0 to 4 V 2 to 12 pH	00.00	-4000	-600	3.5	-3400	10.5
4111					1 to 5 V -.5 to +.5	-1000	-5000	-1600	-0.35	-4400	0.35
4112				X	0 to 4 V 0 to 14 pH	00.00	-4000	-600	2.1	-3400	11.9
4114			Pt		-100 to +100°C	58.96Ω	140.35Ω	72.31Ω	-70	127.08Ω	+70
4115		WRE			1200 to 3200°F	11.23	33.03	20.11	2000	28.37	2800
4116			Pt		0 to 100°C	99.21Ω	139.53Ω	107.80Ω	20	130.90Ω	80
4117		R			0 to 2000°C	-2.22	23.23	4.47	500	10.50	1000
4118		J			200 to 1200°F	4.21	36.34	9.48	350	31.10	1050
4119		J			200 to 1200°F	3.95	36.48	17.19	600	29.52	1000
4120		J			200-2200°F	2.61	71.06	17.18	600	63.39	2000
4121		J			0 to 500°C	-1.11	28.10	10.78	200	21.85	400
4122		K			500-1500°F	9.92	34.59	15.18	700	29.31	1300
4124		K			0 to 600°C	-0.70	25.31	6.14	150	21.07	510
4125		T			0 to 500°F	-0.95	11.13	0.39	50	3.97	200

*Data based upon IPTS-68 for types B,K,J,R,S, and T thermocouples.
Data based upon Hoskins curve for suffix 4145.
Data based upon G.E. for suffixes 4131-33.
Data based upon Engelhard for suffixes 4022,4060,4065,4115,4127 and 4140.

TABLE IV–CALIBRATION DATA (Concluded)

Cat. Suffix	TYPE OF INPUT				OVERALL RANGE	INPUT SIGNALS		LOW CAL. PT.		HIGH CAL. PT.	
	EMF	TC*	Therm-ohm	Other		Low End mV	High End mV	mV	Counter /Scale	mV	Counter /Scale
4126		T			0 to 500 K	-3.47	27.50	12.01	250	20.87	400
4127		P1.II			200 to 1200°C	5.79	51.95	15.67	400	37.59	900
4128			Pt		0 to 200°F	92.61Ω	137.07Ω	118.97Ω	120	125.37Ω	150
4129			Pt		0 to 200°C	99.14Ω	177.19Ω	107.80Ω	20	168.45Ω	180
4130			Pt		0 to 1000°F	22.71Ω	76.29Ω	34.18Ω	200	64.83Ω	800
4131		Ni			500 to 2500°F	5.59	72.57	45.31	1700	51.74	1900
4132		Ni			300 to 1300°C	9.36	67.83	27.60	600	52.45	1050
4133		Ni			300 to 2300°F	1.78	65.09	24.57	1000	61.54	2200
4134		J			-100 to +100°C	-5.35	5.39	1.02	20	4.19	80
4135				X	0 to 4 V(0 to 10 pH)	0.00	-4000	-600	1.5	-3400	8.5
4136				X	1 to 5 V(0 to 10 pH)	-1000	-5000	-1600	1.5	-4400	8.5
4137		B			0 to 2000°C	0.00	15.91	4.83	1000	13.59	1800
4138		J			0 to 800°F	-1.64	23.79	2.53	120	19.64	680
4139		K			0 to 1400°C	-1.55	59.17	11.38	280	43.20	1050
4140		WRE			0 to 1400°C	0.00	25.03	4.34	280	20.30	1120
4141		B			600 to 1600°C	0.81	10.91	3.96	900	6.80	1200
4143				X	0 to 4 V(4-14 pH)	0.00	-4000	-600	5.5	-3400	12.50
4144				X	1 to 5 V(4-14 pH)	-1000	-5000	-1600	5.5	-4400	12.50
4145		WRE			300 to 2300°C	-0.84	42.18	18.65	1200	29.84	1750
4150				X	0 to 10 pH	-53.5	+22.9	-42.04	150	+11.44	850
4151				X	0 to 14 pH	-53.5	+53.5	-37.45	2.1**	+37.45	11.9**
4152				X	2 to 12 pH	-38.2	+38.2	-26.74	350	+26.74	1050
4153				X	4 to 14 pH	-22.9	+53.5	-11.44	550	+42.04	1250
4170		T			-100 to +400F	-2.581	9.523				
4171		T			-100 to +200C	-3.378	9.286				
4172		J			0 to 500F	-0.885	14.108				
4173		J			0 to 1200F	-0.885	35.999				
4174		J			0 to 1500F	-0.885	46.503				
4175		J			0 to 800C	0	45.498				
4176		K			0 to 1200F	-0.692	26.975				
4177		K			0 to 1500F	-0.692	33.913				
4178		K			0 to 2000F	-0.692	44.856				
4179		K			0 to 2400F	-0.692	52.939				
4180		K			1000 to 2000F	22.251	44.856				
4181		K			0 to 1200C	0	48.828				
4182		S			0 to 3000F	-0.092	17.347				
4183		S			1000 to 3000F	4.609	17.347				
4184		S			0 to 1600C	0	16.771				

Calibration points are the low and high ends of each span.

*Data based upon IPTS-68 for types B,K,J, R,S, and T thermocouples.
Data based upon Hoskins curve for suffix 4145.
Data based upon G.E. for suffixes 4131-33.
Data based upon Engelhard for suffixes 4022, 4060, 4065, 4115, 4127, and 4140.

**Analog Scale.

TABLE V—RJ COMPENSATOR VOLTAGES

THERMOCOUPLE TYPE	VOLTAGE BETWEEN TPA & TPB*	RESISTOR** POSITION ON RJ COMPENSATOR
B	No Compensation	-
R & S	2.50 V dc	R/S
J	2.98 V dc	OTHER
K	2.28 V dc	OTHER
T	2.34 V dc	OTHER
WRE	1.94 V dc	OTHER
Platinel II	2.15 V dc	OTHER
NINI - 18% MOLY	3.02 V dc	OTHER

*Located on compensator card, foil side.
**311792 (4.87 k). On WRE use 311924 (24.9 k).

21C. Set Point Zero Adjustment

(1) Set set point to low (zero) end of travel.

(2) Apply dc input corresponding to low (zero) end of scale. This is the mV in the Low End column of Table IV or from the calibration data supplied with the controller (minus mV from 177610 Tables at the reference junction temperature, or adjustment of RJ compensator in the millivolt potentiometer for RJ temperature using 177610 Tables).

(3) Adjust zero pot (Z) at top of controller (forward position) for null reading (0) on the deviation indicator (pointer at center index).

21D. I/O Card* Zero Adjustment (Option - omit if card is not supplied on E studs).

Adjust Z zero adjustment (rear position on I/O card) for reading on input meter corresponding to low end of setter (0 V between E8 and E7)**. Normally this will be a zero indication on the meter measuring 0% of setter range; however, it can be field-adjusted to 0 degrees of any desired range up to 1000° C or F.

21E. Gain Adjustment

Move input to value of +50°F (or C) point (or 0.5 mV for emf instruments) and adjust gain adjustment (G) top of controller, rear position, until meter reads 50° LOW (for digital setters). For analog setters, move input to +10% of input range, and adjust G until meter reads 10% high.

21F. I/O Card Span Adjustment (Option - omit if card is not supplied on E studs).

(1) Inject dc input signal corresponding to 100% of range, using millivoltage from calibration data supplied with instrument or Table IV, High

*Input/Output PC card is used in controller with suffixes E3 to E8 and G1.
**When E8 is inaccessible, use E6 on deviation alarm card if it is connected to E8.

End column. (Adjust for ambient temperature as in Step 2 of Section 21C.)

(2) Adjust I/O S span adjustment (front on card) for full-scale (100%) meter reading, or 5 V dc between E8 and E7. (Negative voltage, when unit is reverse acting.)

(3) Repeat gain adjustment (Section 21E), then set-point-zero adjustment (Section 21C).

21G. Set-Point Span Adjustment

(1) Set set point to 100% of its travel.

(2) Inject dc input signal corresponding to 100% of range, using millivoltage from calibrated data supplied with instrument or Table IV, High End column (adjusting for ambient temperature as in Step 2 of Section 21C) if not done for Step 1 of Section 21F.

(3) Adjust set point span pot (S), top of controller, middle position, for null reading on the deviation indicator (pointer at center index).

21H. I/O Card Balance Adjustment (Optional feature, disregard if card is not supplied.)

(1) With input and setter settings of Sec. 21G, adjust balance pot B (center position on I/O card) until meter reads 100% of scale (or E8 to E7 is 5 V dc) or such other reading as will satisfactorily indicate the temperature equal to 100% of set point range.

(2) Repeat 21D in order to trim out any error in the zero adjustment settings for the set point and I/O PC card. If this adjustment is small (a few percent), go to Section 21J. However, if the readjustment of zero controls involves changes in excess of 1 full turn, repeat steps in 21E through 21G.

21J. Fine Adjustment

(1) Set input to value specified as lower calibrating point on calibration table (adjusted for ambient temperature, if required). See Table IV, Low Cal. Pt. column.

(2) Set setter at corresponding value.

(3) Trim range zero adjustment on main PC card as required to bring deviation meter to zero.

(4) Repeat Steps 1 - 3, except set value corresponding to upper calibrating point, and trim span adjustment. See Table IV, High Cal. Pt. column.

(5) Repeat Steps 1 - 4 until both calibrating points are correct. Touch up I/O card controls if required to reproduce input signals on input meter, or external read-out instrument.

(6) A calibration error occurs when extender card 064219 is used with a thermocouple compensator. This results in a deflection of the deviation meter when the extender card is removed. To correct for this deflection, insert the extender card and controller again, and adjust the set point zero adjustment (R7) for an equal deflection in the opposite direction. The deflection should be zero when the extender card is removed and the controller energized.

21K. Control Amplifier (IC2)

For these adjustments, the driver card must be in place.

(1) Proportional Band Only

(a) Set PB control (front panel) at 20°.

(b) Short stud D5 to D7 (control amplifier input grounded).

(c) Adjust controller zero R55, behind front-panel door above control R, for a zero output at stud D2 when the input is at set point. (Deviation meter at zero.)

(d) Remove short.

(e) Adjust PB control to 200°.

(f) Adjust source until deviation meter reads −50°. Control amplifier output at stud D2 should be −2.5 V (±0.5 V).

(2) Proportional Band and Reset

(a) Set PB control at 20° and Reset control at 0.5.

(b) Short stud D5 to D7.

(c) Adjust control zero Z behind front-panel door above control R, for a steady output at D2. If the output is at a limit (0 V or −12 V), first adjust Z control to obtain an output between 0 V and −5 V and then adjust for steady output (over a 2-minute period).

(d) Remove short.

(e) Adjust PB control to 200°.

(f) Adjust source until deviation meter reads zero.

(g) Let a Reset setting between 0.5 to 5 and a smaller error signal (+ or −) bring the control output at D2 to −2 V (approximately).

(h) Change Reset to 0.05.

(i) Adjust source until deviation meter reads −50°. Control output at D2 should be −4.5 V (approximately).

(j) Adjust Reset to approximately 1. Control output at D2 should increase from −4.5 V toward −10 V. (About −2.5 V in 1 minute if Reset setting is accurate.)

(3) Approach

(a) Set PB control at 100 and Reset at 0.05.

(b) Adjust set point to 50% of full range and source to minimum range so that the feedback signal at D2 is typically −10 V, or −16 V for P.A.T. driver or −7 to −9 V for C.A.T. driver.

(c) Set Approach control A at maximum (100).

(d) Adjust approach calibration potentiometer on approach card 444865 so that 2 V (+ or −) is produced at the tie-point on approach card (junction of 10 k approach control and 1 meg Reset control).

(4) Rate

(a) Adjust PB control to 200° and Reset control to 0.05. Adjust source to get −2 V at control output. (Increase Reset to speed up zeroing.)

(b) Apply an 0.2 V step signal to the controller input (terminals 14 and 13). The controller output should change between −5 and −10 V.

21L. Input/Output Card Calibration

(1) Input (E) Position

Calibration of I/O card is part of range calibration. See Sec. 21C to 21J.

(2) Output (D) Position

When a manual station is provided, depress the front-panel M button to monitor the output on the deviation meter.

(a) Adjust input or set point for a zero controller output (C.A.T. - 0 mA, D.A.T. - full off, etc.). Set zero (Z) pot for a 0 meter reading, or 0 volts at D8 (D7 common).

(b) Adjust input or set point for maximum controller output (C.A.T. - 5 mA, D.A.T. - full on, etc.). Set balance (B) for full-scale meter reading, or 5 volts at D8 (D7 common).

(c) Recheck steps (a) and (b) so that the meter full strokes from 0 to 100% for a nominal 0 to 100% of controller output.

21M. C.A.T. Driver Card Adjustment (444857 & 444872)

(1) Turn Max. Current Adj. (G) on driver card to CCW extreme.

(2) Increase input signal until the driver input voltage (A6-B3) is +10.5 V dc.

(3) Rotate (G) clockwise until the load current reaches its maximum rated value (5 mA or 20 mA).

22. RECOMMENDED SPARE PARTS

Replacements are recommended for the driver card, option cards, input range resistors and set point potentiometer of your particular controller, as well as a manual station card and ATR relay, and triac assembly, where applicable. The part numbers are listed in Tables I to IV of the appendix for each type of controller, control and alarm feature, etc. In addition, the (Δ) components listed in the parts lists are recommended as spare parts if the controller is to be field repaired.

APPENDIX

The tables and figures in the Appendix identify the principal parts of each Electromax III controller according to its catalog number as well as provide the schematic diagrams, assemblies and parts lists of each assemblies and parts lists of each assembly and a number of separate parts.

Table AI lists the driver cardused in each type of controller or alarm, and triac assembly and manual station when specified. When a manual station is present, an I/O card (444862) is required in the D stud position. An ATR relay (F2, 3, 6 or 7) provides bumpless transfer.

TABLE AI—PART NUMBERS OF DRIVER CARDS, TRIAC ASSEMBLIES AND MANUAL STATIONS

CAT. NO.	TYPE	RESISTORS WITH LUGS R60	DRIVER CARD	TRIAC ASSEMBLY	MANUAL STATION CARD
6430	V.A.T. Controller	310913 (R49 & R60)	-	-	-
6431	P.A.T. Controller	310914	444870	-	444969(1)
6432	C.A.T. (Hard)Controller	310915	444872	-	444967(2)
6433	D.A.T. Controller	310916	444869(6)	173071(3)	444967(2)
6434	P.E.T. Controller		444871	173072(4)	444967(2)
6435	C.A.T. (Soft)Controller	310915	444857	-	444968(5)
6437	ON-OFF Controller		444858(7)	173071(3)	
6438	Overheat Alarm		444859	-	

(1) When G5 is specified.
(2) When G3 is specified.
(3) When H21 is specified.
(4) When H22 is specified.
(5) When G4 is specified.
(6) When J805 is specified, 445279 is substituted.
(7) When J805 is specified, 445280 is substituted.

Table AII lists the combinations and positions of the option cards for various catalog suffixes. Where more than one card is located in one stud position, see Sec. 7E(8).

TABLE AII—PART NUMBERS OF OPTION CARDS

FUNCTION	CAT. SUFFIX	CARD	POSITION ON STUDS(D or E)
Approach	D4, D5	444865	D
Input Meter	G1	444862	E
1 Deviation Alarm	E1	444866	E
2 Deviation Alarms	E2	2-444866	E
1 Input Alarm	E3	444866	E
		444862	E
1 Input & 1 Dev. Alarm	E4	2-444866	E
		444862	E

TABLE AII—PART NUMBERS OF OPTION CARDS (Cont'd)

FUNCTION	CAT. SUFFIX	CARD	POSITION ON STUDS(D or E)
2 Input Alarms	E5	2-444866 444862	E E
1 Output Signal & 1 Input Alarm	E6	444862 444862	D E
High Output pro-portional to input	E7	444862	E
High Output pro-portional to input + Dev. Alarm	E8	444866 444862	E E
Manual Station Out Meter	G3-G5	444862	D
Output Meter	G2	444862	D
Dual Control	870 Option	445258	D

Table AIII lists many of the components and parts found in the Electromax controller, as well as miscellaneous hardware.

Table AIV lists the plug-in resistors and counter or analog scale required for each input range (Cat. Suffix C). The value of each resistor can be found under its L&N number in Table AV.

TABLE AIII—PART NUMBERS OF MISCELLANEOUS COMPONENTS

FUNCTION	CAT. SUFFIX	COMPONENT	L&N PART NO.
Proportional Band	DI-D5	Potentiometer, R58 - I k	013604
Reset	D2-D5	Potentiometer, R57 - I M	013603
		Capacitor, C52 - 0.47 μF	023367
		Capacitor, C53 - 1200 μF	023587
Rate	D2 & D5	Potentiometer, R56 - I M	013602
		Rate Capacitor Assembly	023805
	D0,D2,D4	Resistor, I Meg.	310917
Dev. Meter - Analog	B2-B8		021207
Dev. Meter - Digital	B2-B8	25-0-25 μA dc Meter	021205
Output Meter	G2	0.25-0-0.25 mA dc Meter	021209
Input Meter	GI	0.25-0-0.25 mA dc Meter	021209
Approach	D4,D5	Potentiometer, R59 - I0 k	013605
Set Point Setter -			
Analog	B3/B4	Potentiometer, R50 - I kΩ	013559
Digital	B5/B6	Potentiometer, R50 - I kΩ, 2W	013609
Prec. Digital	B7/B8	Potentiometer, R50	013606
Arc Suppressor			171070
Remote-Local Switch	B3/B5/B7	R/L Switch	032475
ATR Relay	F2/F3/F6/F7	ATR Relay	036574
	HI0/H20/H2I/		
Terminal Board	H22	Terminal Board	316330
Case	H20/H2I/H22	Aluminum Case	339248
Current Input Shunt			
0-40/I0-50 mA	J8I0	Resistor - I00.5 ohms	310983
0-I6/4-20 mA	J8II	Resistor - 253.2 ohms	310984
0-4/I-5 mA	J8I2	Resistor - I052.6 ohms	310985
Analog Setter Kit			324143
Red Panel Lamp		Assembly	026284
Amber Panel Lamp		Assembly	026285
Neon Lamp		Assembly	026286
Overheat Reset Switch		Assembly	031603
Plug Button			042218
Case Cover (at rear)			267632
Case Cover - Perforated			
for Triac Assembly (at rear)			267717
Front Panel Knob		Front Panel Knob	002358
		Coil Spring	028475
		Top Support Bracket	273887
		Controller Mounting Bracket	273884
		Controller Index Bracket	273886
		Stiffening Strap	273896
		Spacer for Mounting Bracket	301299
		Sliding Door	339237
		Bezel	066284
	B3,B4	Analog Window	066282
	B3,B4	Analog Drum	120136
Setter Lock Button			042213
		Leaf Spring	028472
Studs for Option Cards		25/32 in. Spacer	301318
		29/32 in. Spacer	301335
		Spacer with outside thread	301317
Manual Stations			
Manual Adj. Pushbuttons	G3	Knob for R5	002355
Lower	G4,G5	L	042227
Meter	G3-G5	M	042228
Automatic	G3-G5	A	042229
Raise	G4,G5	R	042230
Filler Plate	G4,G5		369342
Filler Plate	G3		369343
Support Bracket			369338
Front Panels			
Digital	B6,G0		369146
	B6,GI-G5		369145
	B5,B7,GI-G5*		369378
Analog	B4,G0		369148
	B4,GI-G5		369147
	B3,GI-G5*		369379
Remote	B2,G0		369149
(with Dev. Mtr.)	B2,GI-G5		369377
Blank Plate	BI,G0*		369150
(no Dev. Mtr.)	BI,GI-G5		369150
Plate			369341
pH STD Adj. and	J880	Potentiometer, I0 kΩ, I0W	013634
Input PC Card		Resistors, 3I.5 k, I/4 W, I%	
		in Y&G leads of pot.	311789
		Resistor, I8 k, I/4 W, I%	
		in R lead of pot.	311789
		pH Input PC Card	445259

*Panel Option Blanking.

TABLE AIV—PART NUMBERS OF PROGRAMMABLE RESISTORS* COUNTERS AND SCALES

CAT. SUFFIX (C)	SPAN RES. R2	ZERO RES. R6	GAIN RES. R5	LIN. RES. R34	DIGITAL CTR. KIT (B5-B8)	ANALOG SCALE (B3 or B4)
4001	311923	311458	411434	310919	324157	058579
4002	311832	311458	311785	310921	324158	058580
4003	311771	311458	311068	310922	324160	058581
4004	311783	311791	411404	310921	324158	058583
4005	311775	311791	411404	310919	324157	058584
4006	311775	311791	411404	310919	324158	058583
4007	311775	311791	411434	310919	324157	058584
4008	311783	311791	411436	310921	324158	058583
4009	311783	311791	411436	310921	324157	058584
4010	311783	311791	411436	310921	324158	058583
4011	311775	311791	411404	310919	324157	058584
4012	311749	311458	411301	310914	324158	058587
4013	311749	311458	411301	310914	324157	058592
4014	311749	311832	411301	310914	324158	058587
4015	311749	311832	411385	310914	324157	058592
4016	311924	311782	411381	310920	324158	058590
4017	311924	311782	411381	310920	324157	058591
4018	311924	311458	411381	310920	324158	058587
4019	311924	311458	411381	310920	324157	058592
4020	311782	311458	411462	310937	324157	058592
4021	311782	311458	411462	310937	324159	058593
4022	311782	311832	411462	310937	324158	058594
4023	311782	311782	411403	310937	324157	058584
4024	311774	311789	411403	310937	324157	058595
4026	311924	311832	411381	310920		058621
4027	311924	311924	411381	310920		058622
4028	311749	311749	411301	310914		058623
4029	311782	311924	411462	310937		058624
4030	311923	311458	411434	310919	324157	058592
4031	311923	311458	411434	310919	324158	058587
4032	311923	311458	411434	310919	324159	058593
4033	311923	311458	411434	310919	324157	058592
4034	311783	311832	411436	310921	324159	058593
4035	311799	311782	311780	310919	324157	058581
4036	311774	311832	411403	310937	324158	058587
4037	311924	311791	411381	310920	324158	
4040	311774	311775	411403	310921	324159	
4041	311782	311832	411462	310937	324157	058592
4042	311783	311458	411404	310921	324159	058637
4043	311783	311832	411436	310921	324157	058616
4044	311775	311832	411434	310919	324158	
4045	311783	311832	411436	310921	324159	058593
4046	311923	311791	411434	310919	324160	058592
4048	311923	311458	411434	310919		
4049	311783	311832	411436	310921	324159	058637
4050	311832	311791	311785	310921		058636
4051	311774	311782	411403	310937	324157	
4052	311774	311791	411403	310937	324157	058640
4053	311774	311832	411403	310937	324157	058592
4055	311923	311832	411434	310919	324158	
4056	311749	311832	411385	310914	NA	058647
4057	311832	311458	311785	310921		058631
4059	311775	311832	411404	310919	324158	
4060	311832	311832	311785	310921	324157	
4061	311782	311458	411306	310937	324158	058594
4064	311924	311458	411381	310920	324157	058579
4065	311924	311832	411381	310920	324157	
4069	311775	311781	411404	310919	324157	058584
4070	311924	311458	411381	310920	324159	058593
4071	311782	311832	411462	310937	324157	058579
4072	311782	311832	411462	310937	324157	058592

*Input resistor R3 - 311780: except for suffixes 4001-3, 4070, 4090 - 311774, and for suffixes 4079, 4080, 4089 and 4137 - 311799.
NA - Not available as standard.

TABLE AIV–PART NUMBERS OF PROGRAMMABLE RESISTORS* COUNTERS AND SCALES (Concluded)

CAT. SUFFIX (C)	SPAN RES. R2	ZERO RES. R6	GAIN RES. R5	LIN. RES. R34	DIGITAL CTR. KIT (B5-B8)	ANALOG SCALE (B3 or B4)
4078	311783	311774	411436	310921	324159	058593
4079	311458	311458	411785	310921	NA	058739
4080	311923	311458	411434	310919	324159	058593
4081	311779	311832	411301	310914	324158	058587
4082	311774	311832	411303	310937	324158	058587
4083	311782	311791	411462	310937	324159	058593
4084	311775	311832	411404	310919	324158	058590
4089	311891	311458	411434	310919	NA	NA
4090	311546	311458	311775	310919		
4093	311775	311832	411404	310919	324157	058591
4095	311832	311924	411403	310921	324157	
4096	311783	311832	411436	310921	324159	058593
4100	311832	311832	311785	310921	324157	058592
4101	311832	311832	311785	310921	324158	058587
4102	311832	311832	311785	310921	324159	058593
4103	311832	311832	311785	310921	324160	058592
4105	311832	311832	311785	310921	324157	058592
4106	311832	311832	311785	310921	324158	058587
4107	311832	311782	311785	310921	324159	058593
4108	311832	311782	311785	310921	324160	058592
4110	311832	311458	311785	310921	324157	058616
4111	311832	311782	311785	310921		058631
4114	311924	311782	411306	310914		058632
4115	311832	311782	311785	310921	324158	
4116	311458	311749	311785	310921	324157	058581
4117	311774	311458	411403	310937	324158	058587
4118	311782	311782	411462	310937	324157	058640
4119	311782	311782	411462	310937	324157	058640
4120	311749	311458	411301	310914	324158	058646
4121	311782	311832	411462	310937	324159	058593
4122	311774	411462	411403	310937	324157	058584
4124	311774	311832	411403	310937		058636
4125	311775	311832	411404	310921	324159	058593
4126	311832	311832	411403	310921	324159	058593
4127	311924	311774	411381	310914	324157	058640
4128	311832	311749	411785	310921	324158	058641
4129	311832	311779	411306	310937	324158	058641
4130	311749	311832	411381	310914	324157	058579
4131	311749	311832	411301	310914	324158	058590
4132	311749	311832	411301	310914	324157	058591
4133	311749	311832	411301	310914	324158	058594
4134	311923	311458	411434	310919		058632
4135	311832	311832	311785	310921	324157	058579
4136	311832	311774	311782	310921	324157	058579
4137	311832	311783	411403	310921	324158	058587
4138	311774	311832	411403	310921		058648
4139	311749	311458	411301	310914		058647
4140	311782	311458	411462	310937		058647
4141	311923	311832	411434	310919	324157	
4143	311832	311458	311785	310921	324157	058738
4144	311832	311774	311782	310921	324157	058738
4145	311924	311832	411306	310914	324158	058594
4150	311779	311782	311068	310922	324157	058579
4151	311785	311782	411303	310922	NA	058628
4152	311779	311782	311068	310922	324157	058616
4153	311779	311782	311068	310922	324157	NA
4170	311783	311832	411404	310919		358050
4171	311783	311832	411404	310919		358051
4172	311783	311774	411436	310921		358052
4173	311924	311774	411306	310937		358054
4174	311924	311774	411381	310920		358055
4175	311924	311832	411381	310920		358053
4176	311782	311774	411462	310937		358064
4177	311924	311774	411306	310920		358057
4178	311924	311774	411381	310920		358058
4179	311749	311774	411301	310914		358060
4180	311774	311924	411403	310921		358059
4181	311749	311774	411381	310920		358056
4182	311458	311774	311785	310921		358062
4183	311783	311832	411404	310919		358063
4184	311458	311774	311785	310921		358061

*Input resistor R3 - 311780: except for suffixes 4001-3, 4070, 4090,- 311774, and for suffixes 4079, 4080, 4089 and 4137 - 311799.
For suffixes 4150-3, R3 is replaced by R3A - 311924 for 4150, 4152 and 4153; 311749 for 4151.
NA - Not available as standard.

TABLE AV—RESISTANCE VALUES OF PROGRAMMABLE RESISTORS*

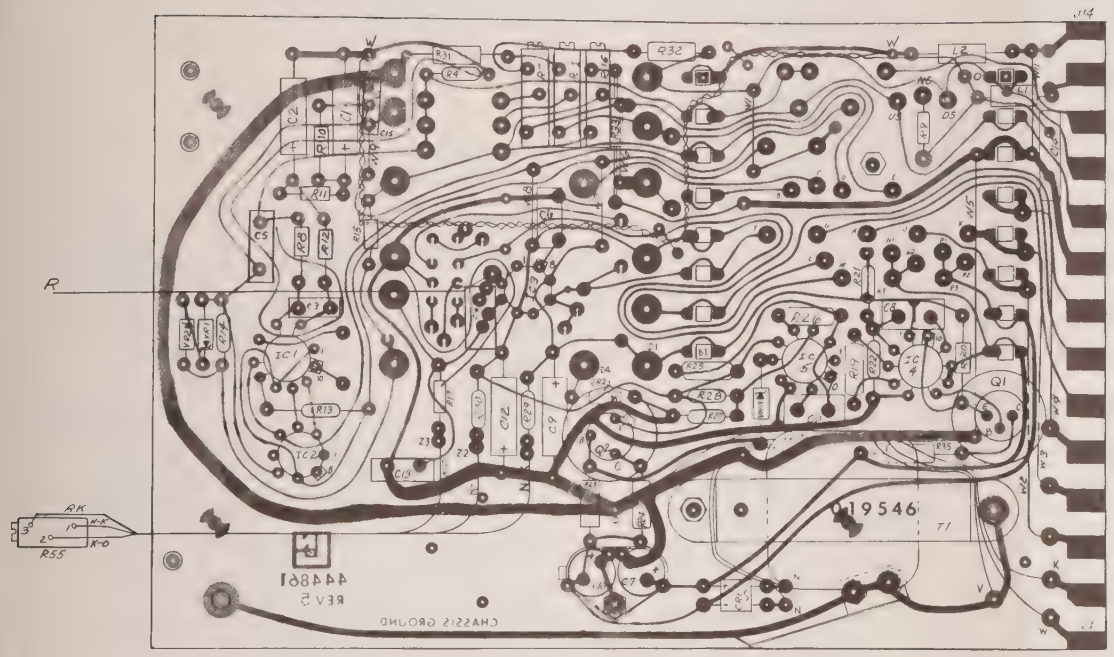
L & N PART NO.	RESISTANCE	L & N PART NO.	RESISTANCE
310913	8.25k + 10k	311832	56.2k
310914	6.19k	311923	124k
310915	1.33k	311924	24.9k
310916	2.0k	411301	3.01k
310917	1.0 Meg.	411303	1.5k
310918	3.92k + 31.5k	411306	5.11k
310919	8.25k	411381	3.92k
310920	6.65k	411385	3.32k
310921	7.5k	411388	30.1k
310922	5.62k	411403	8.25k
310937	7.15k	411404	15k
311068	2.0k	411434	18.2k
311439	6.04k	411436	13k
311458	68k	411462	6.19k
311546	500k		
311749	18k		
311771	12k		
311774	49.9k		
311775	100k		
311779	15k		
311780	20k		
311781	100k		
311782	35.7k		
311783	82.5k		
311785	10k		
311789	31.5k		
311791	47k		
311792	4.87k		
311799	133k		

*See Table AIV.

The following figures are the schematic diagrams and assembly drawings of:

Fig.	Description
A1	Basic controller PC card 444861
A2	Driver cards and triac assemblies
A3	Option cards
A4	Input circuits and compensators
A5	Manual stations, polarity reversing switch and Remote/Local switch circuits
A6	Ratio and Cascade Circuits
A7	Dual control circuits
A8	pH 7773/7779 Transmitter to Electromax III interconnections

Recommended spare parts are indicated by a (Δ).



444861 CARD CONTROLLER

SYMBOL	DESCRIPTION	PART NO.
△C1,C2,C9,C12	CAPACITOR 22UF, 15V	023303
C6	CAPACITOR 100PF, 500V	023596
C3,C5	CAPACITOR 47 PF, 500V	023328
C14	CAPACITOR 0.02UF, 450V	023
	CAPACITOR 100UF, 40V	
△ ,C16	CAPACITOR 430PF, 500V	
13	CAPACITOR 0.1UF, 30V	023330
C15	CAPACITOR 0.47 UF, 25V	023367
△	DIODE BRIDGE	057115
	DIODE 5669G	188044
△	INTEGRATED CIRCUIT	193208
△	INTEGRATED CIRCUIT	
△	INTEGRATED CIRCUIT	
△	INTEGRATED CIRCUIT	
△ ,L2	CHOKE 56UH	019407
△	TRANSISTOR 2N3053	188173
△	TRANSISTOR 2N4037	188243
,R1	POTENTIOMETER 5K, ½W, 10%	013679
R4,R3	RESISTOR 100Ω, ½W, 1%	311787
△	POTENTIOMETER 10K, ½W, 10%	013678
,R29,R30	RESISTOR 5.11K, ½W, 10%	411306
	RESISTOR 82M, ½W, 10%	
,R11	RESISTOR 1.5K, ½W, 10%	311106
	RESISTOR 1M, ½W, 1%	311891
	RESISTOR 24.9K, ½W, 1%	311924
	RESISTOR 2M, ½W, 1%	311068
, ,	RESISTOR 2.94K, ½W, 1%	311781
R20	RESISTOR 6.8Ω, ½W, 10%	011118
R21	RESISTOR 6.2K, ½W, 1%	311795
	RESISTOR 5.6K, ½W, 1%	311794
	RESISTOR 1K, ½W, 1%	011864
,R5	RESISTOR 1K, ½W, 10%	011130
	RESISTOR 14K, ½W, 1%	411093
R28	RESISTOR 4.32K, ½W, 1%	311748
R31	RESISTOR 4.87K, ½W, 1%	311792
R32	RESISTOR 7.15K, ½W, 1%	311773
R17	RESISTOR 39M, ½W, 10%	311704
△R55	POTENTIOMETER 10K, ½W,	013308
△T1	POWER TRANSFORMER	019546
△VR1,VR2,VR3	ZENER DIODE 6.2V	188124

EE6153

Fig. A1(a)–Electromax III controller PC card assembly (444861).

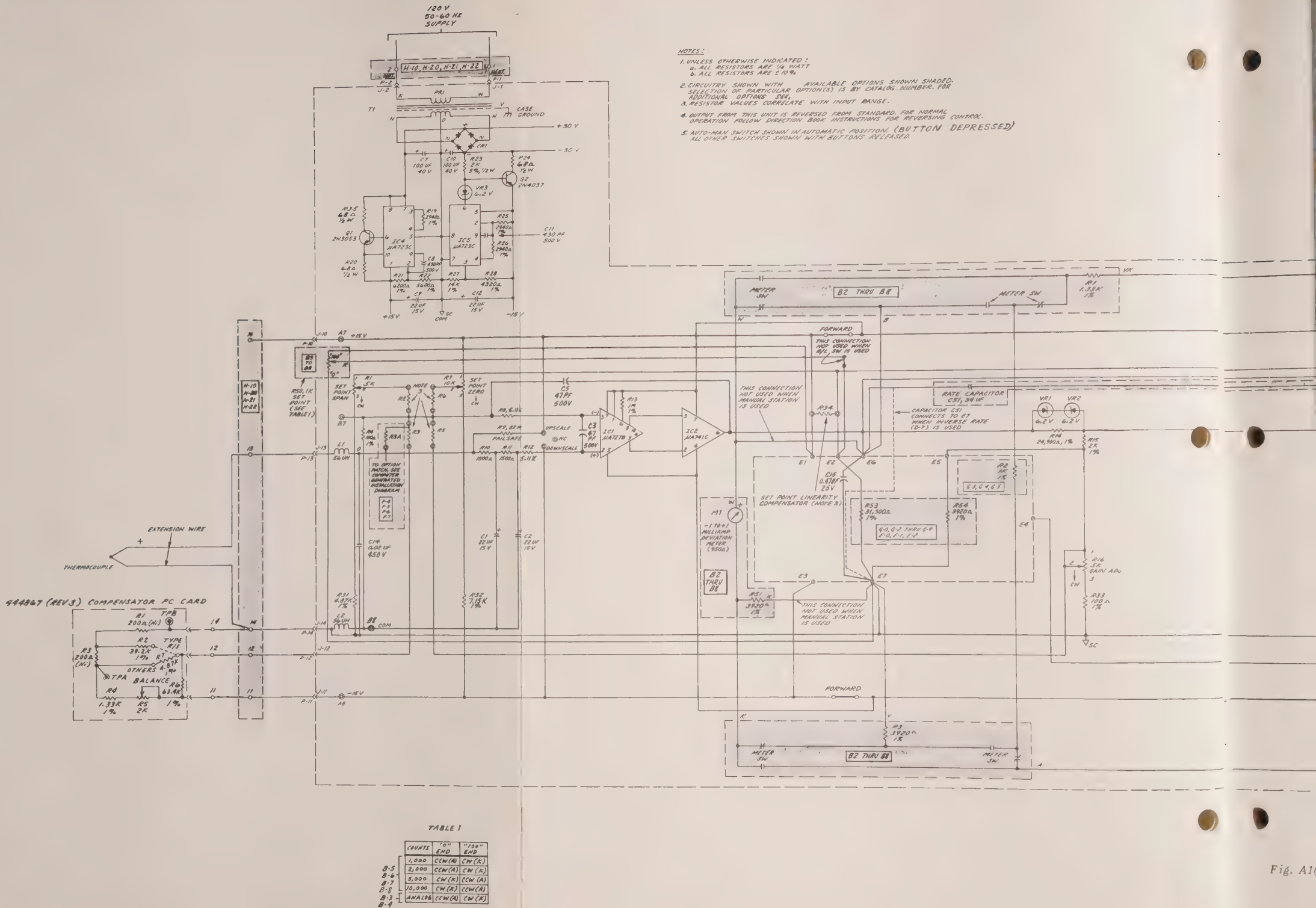
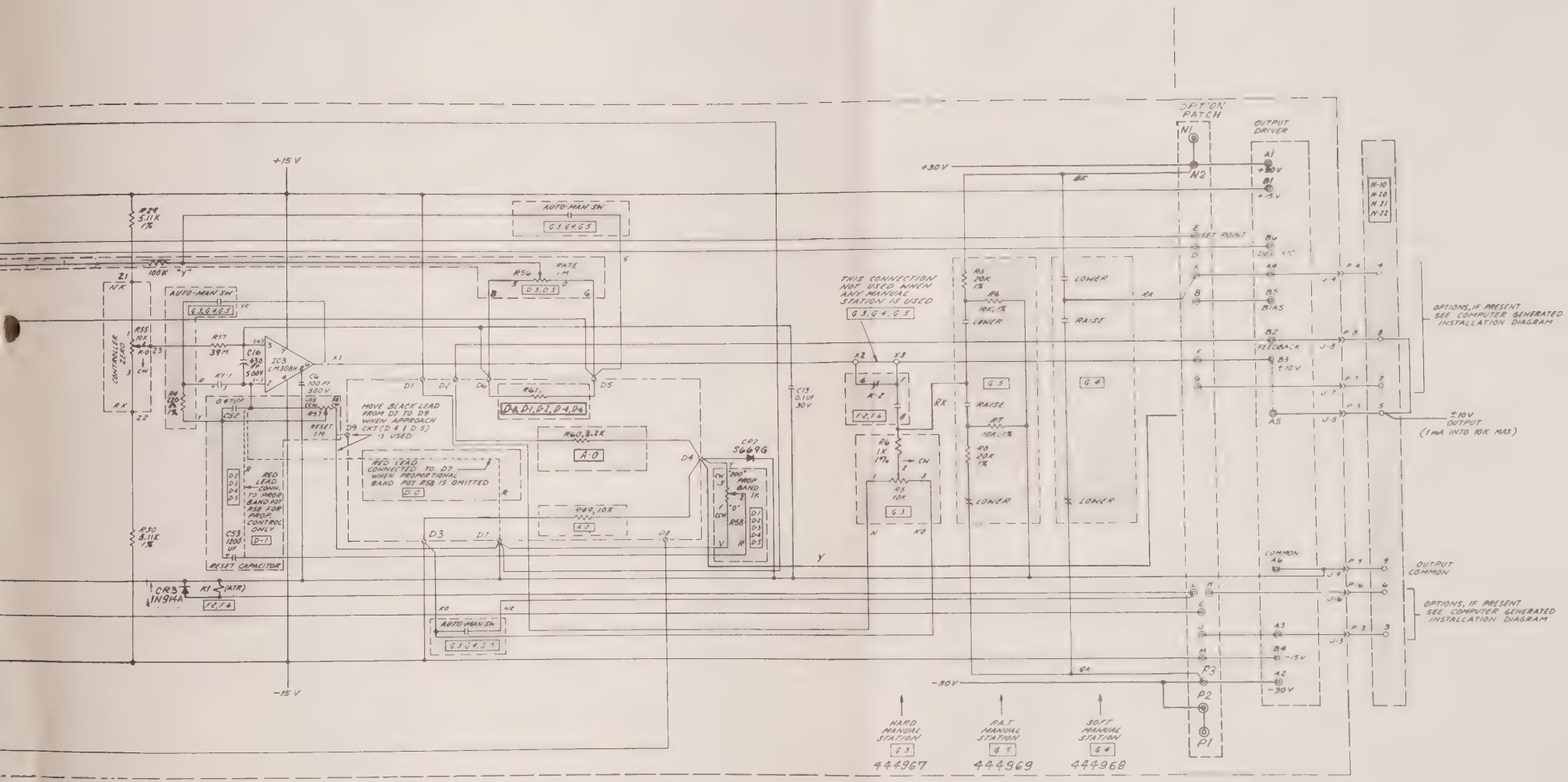

120 V 50-60 HZ SUPPLY
H-10, H-20, H-21, H-22
T1
CR1
Q1 2N3053
Q2 2N4037
VR3 6.2 V
IC4 µA723C
IC5 µA723C
C11 430 PF 500 V
+15 V
-15 V
SC COM
NOTES:
1. UNLESS OTHERWISE INDICATED:
a. ALL RESISTORS ARE 1/4 WATT
b. ALL RESISTORS ARE ± 10%
2. CIRCUITRY SHOWN WITH AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER. FOR ADDITIONAL OPTIONS SEE.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. OUTPUT FROM THIS UNIT IS REVERSED FROM STANDARD. FOR NORMAL OPERATION FOLLOW DIRECTION BOOK INSTRUCTIONS FOR REVERSING CONTROL.
5. AUTO-MAN SWITCH SHOWN IN AUTOMATIC POSITION. (BUTTON DEPRESSED) ALL OTHER SWITCHES SHOWN WITH BUTTONS RELEASED.
METER SW
B2 THRU B8
FORWARD
THIS CONNECTION NOT USED WHEN R/L SW IS USED
THIS CONNECTION NOT USED WHEN MANUAL STATION IS USED
RATE CAPACITOR C51, 39 uF
CAPACITOR C51 CONNECTS TO E7 WHEN INVERSE RATE (D-T) IS USED
SET POINT LINEARITY COMPENSATOR (NOTE 3)
M1 -1 TO +1 MILLIAMP DEVIATION METER (950Ω)
IC1 µA727B
IC2 µA741G
UPSCALE
DOWNSCALE
FAILSAFE
SET POINT SPAN
SET POINT ZERO
EXTENSION WIRE
THERMOCOUPLE
944867 (REV 3) COMPENSATOR PC CARD
TPB BALANCE
TYPE R/S
OTHERS
TO OPTION PATCH, SEE COMPUTER INTEGRATED INSTALLATION DIAGRAM

TABLE 1

	COUNTS	"0" END	"100" END
B-5	1,000	CCW (A)	CW (K)
B-6	2,000	CCW (A)	CW (K)
B-7	5,000	CW (K)	CCW (A)
B-8	10,000	CW (K)	CCW (A)
B-3 B-4	ANALOG	CCW (A)	CW (K)

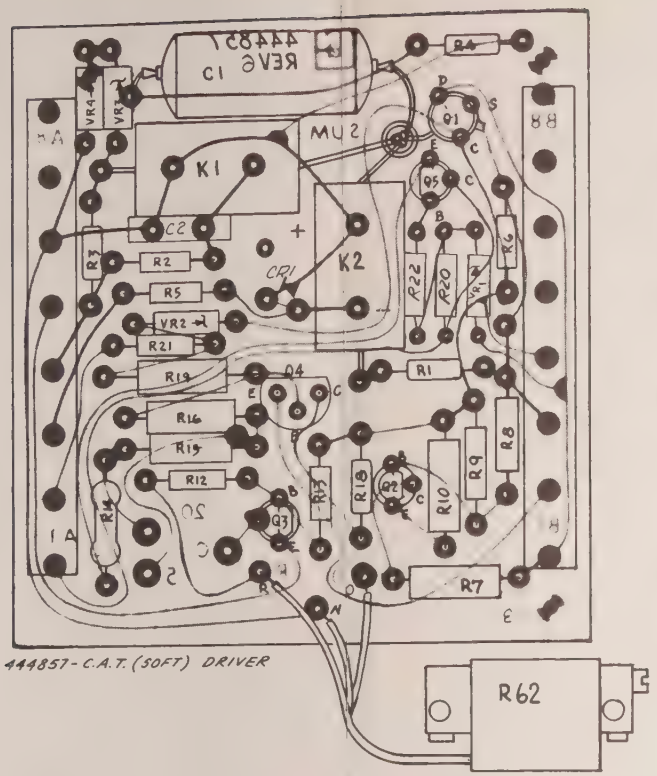
Fig. A1(

COLOR CODE					
1	N	BROWN	6	B	BLUE
2	R	RED	7	V	VIOLET
3	O	ORANGE	8	A	GRAY
4	Y	YELLOW	9	W	WHITE
5	G	GREEN	0	K	BLACK

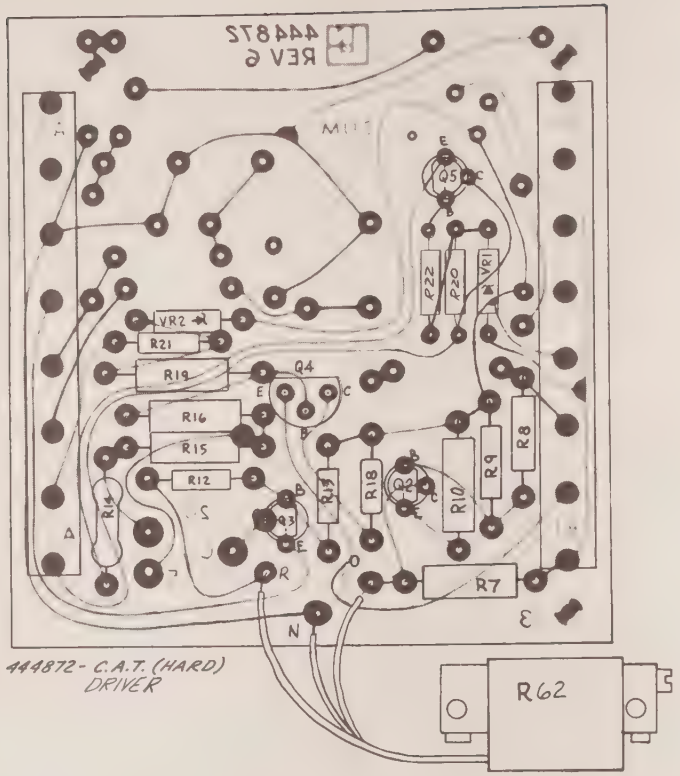


EE6421

Fig. A1(b)–Schematic diagram of 6430 Series Electromax III controller. See Fig. A2(f) to (l) for driver circuits and A3(c) & (d) for option card circuits.



444857 - C.A.T. (SOFT) DRIVER



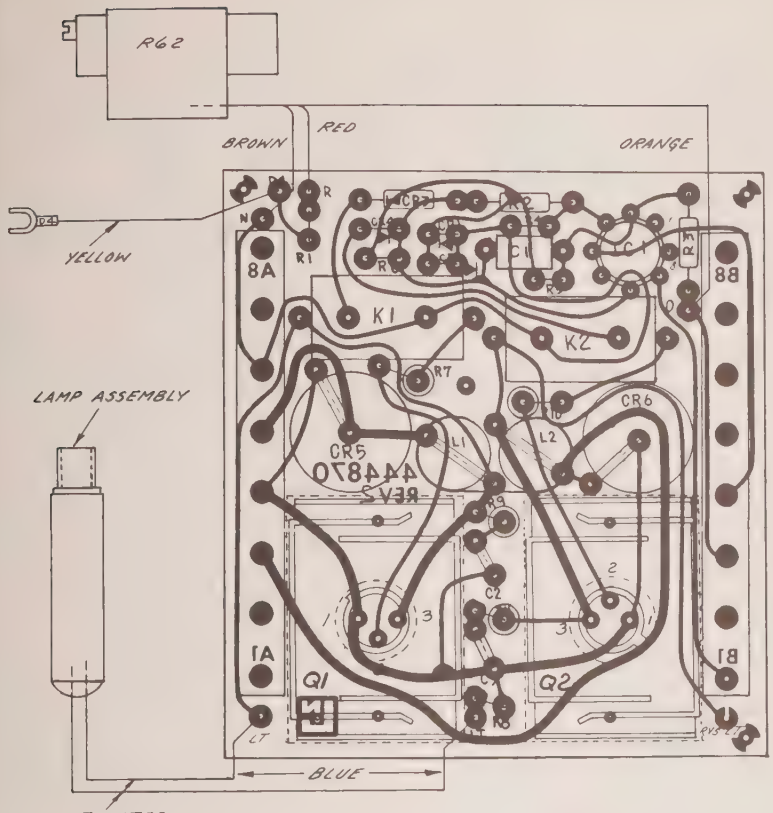
444872 - C.A.T. (HARD) DRIVER

SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 2UF, 50V	023678
C2	CAPACITOR 0.047UF, 25V	023367
CR1	DIODE IN914A	188056
△ K1	RELAY (NO)	032620
△ K2	RELAY (NC)	032660
△ Q1	TRANSISTOR SF5613	188252
△ Q2,Q3,Q5	TRANSISTOR 2N3417	188182
△ Q4	TRANSISTOR 2N6011	188352
R1	RESISTOR 3.3K, ¼W, 5%	311253
R2	RESISTOR 1.8K, ¼W, 10%	311722
R3	RESISTOR 8.2M, ¼W, 10%	311511
R4,R12	RESISTOR 10K, ¼W, 10%	011773
R5	RESISTOR 330Ω, ¼W, 10%	311723
R6	RESISTOR 33K, ¼W, 10%	011988
R7,R10	RESISTOR 5.6K, ¼W, 1%	311794
R8	RESISTOR 10K, ¼W, 1%	311785
R9	RESISTOR 12K, ¼W, 1%	311771
R13	RESISTOR 390K, ¼W, 10%	311705
R14	RESISTOR 511Ω, ¼W, 1%	411452
R15	RESISTOR 1.5K, ¼W, 1%	411303
R16	RESISTOR 47K, ¼W, 1%	311791
R18	RESISTOR 1K, ¼W, 10%	011934
R19	RESISTOR 41.2K, ¼W, 1%	311921
R20,R21	RESISTOR 2.2K, ¼W, 10%	011927
R22	RESISTOR 470Ω, ¼W, 10%	011765
R62	POTENTIOMETER ASSEMBLY 50K	013618
△ VR1,VR2	ZENER DIODE 8.2V	057178
△ VR3,VR4	ZENER DIODE 14V	188281

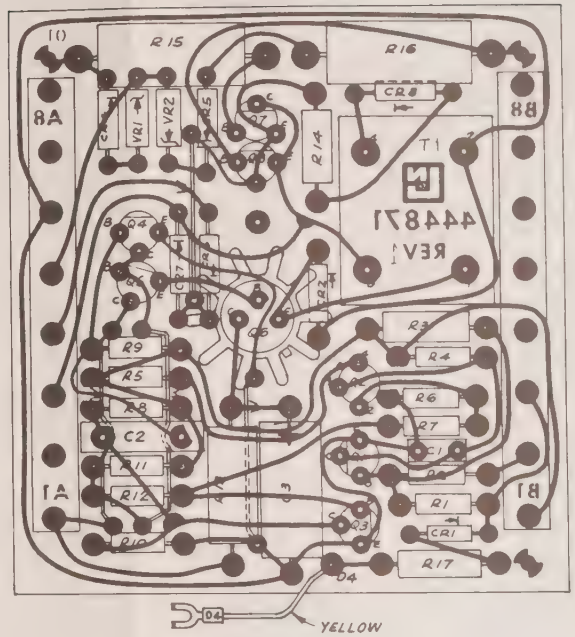
SYMBOL	DESCRIPTION	PART NO.
R7,R10	RESISTOR 5.6K, ¼W, 1%	311794
R8	RESISTOR 10K, ¼W, 1%	311785
R9	RESISTOR 12K, ¼W, 1%	311771
R12	RESISTOR 10K, ¼W, 10%	011773
R13	RESISTOR 390K, ¼W, 10%	311705
R14	RESISTOR 511Ω, ¼W, 1%	411452
R15	RESISTOR 1.5K, ¼W, 1%	411303
R16	RESISTOR 47K, ¼W, 1%	311791
R18	RESISTOR 1K, ¼W, 10%	011934
R19	RESISTOR 41.2K ¼W, 1%	311921
R20,R21	RESISTOR 2.2K, ¼W, 10%	011927
R22	RESISTOR 470Ω, ¼W, 10%	011765
R62	POTENTIOMETER ASSEMBLY 50K	013618
△ Q2,Q3,Q5	TRANSISTOR 2N3417	188182
△ Q4	TRANSISTOR 2N6011	188352
△ VR1,VR2	ZENER DIODE 8.2V	057178

CE6351

Fig. A2(a)–C.A.T. driver card assemblies (444857 & 444872).



444870 - P.A.T. DRIVER



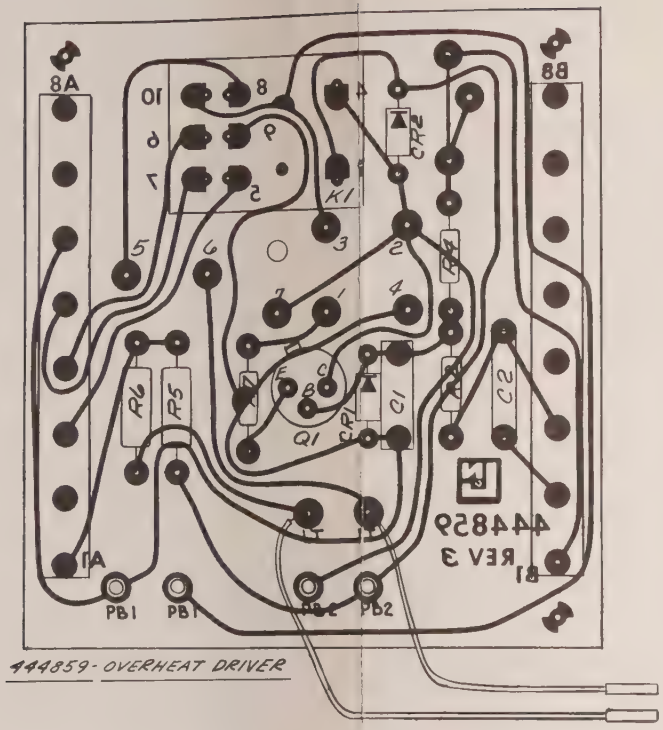
444871 - P.E.T. DRIVER

SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 0.22UF, 50V	023542
C2,C3	CAPACITOR 0.2 UF, 450V	023096
Δ CR1,CR2,CR3,CR4	DIODE IN914A	188056
Δ CR5,CR6	THYRECTOR	057199
Δ IC1	INTEGRATED CIRCUIT μA741C	193207
Δ K1,K2	RELAY	032621
Δ L1,L2	CHOKE 100UH	019451
Δ Q1,Q2	TRIAC RCA 39542	057174
R1	RESISTOR 6.8K, ¼W, 10%	011770
R2	RESISTOR 150K, ¼W, 10%	011769
R3	RESISTOR 10K, ¼W, 10%	011773
R4	RESISTOR 2.7K, ¼W, 10%	311301
R5	RESISTOR 3.3K, ¼W, 5%	311253
R6	RESISTOR 2.2K, ¼W, 5%	311745
R7,R10	RESISTOR 3.3K, ¼W, 10%	011150
R8	RESISTOR 68K, ¼W, 10%	011943
R9,R11	RESISTOR 82Ω, ¼W, 10%	011131
R62	POTENTIOMETER ASSEMBLY 10K	013637
	LAMP ASSEMBLY	026286

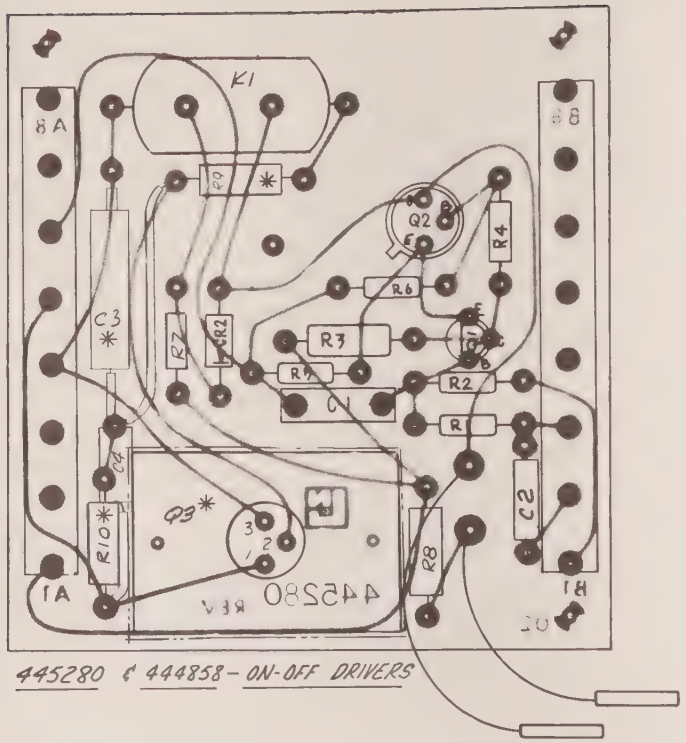
SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 0.015UF, 25V	023628
C2	CAPACITOR 0.02UF, 450V	023096
C3	CAPACITOR 68UF, 30V	023750
CR1	DIODE IN914A	188056
CR2,CR3,CR4, Δ CR5,CR6,CR7	DIODE IN4004	057134
Δ Q1,Q3,Q4,Q7	TRANSISTOR 2N3415	188221
Δ Q2	TRANSISTOR D5E43	188229
Δ Q5	TRANSISTOR 2N3417	188182
Δ Q6	TRANSISTOR 2N2219A	188299
Δ Q8	TRANSISTOR 2N3702	188191
R1,R2	RESISTOR 22K, ¼W, 10%	011771
R3	RESISTOR 215K, ¼W, 1%	311788
R4	RESISTOR 10K, ¼W, 10%	011773
R5	RESISTOR 470Ω, ¼W, 10%	011765
R6	RESISTOR 100Ω, ¼W, 10%	011994
R7	RESISTOR 5.6K, ¼W, 10%	311116
R8	RESISTOR 3.3K, ¼W, 5%	311253
R9	RESISTOR 6.8K, ¼W, 10%	011770
R10	RESISTOR 4.7K, ¼W, 10%	311112
R11	RESISTOR 8.2K, ¼W, 10%	311297
R12	RESISTOR 47K, ¼W, 10%	311111
R13	RESISTOR 220Ω, 1W, 10%	011246
R14	RESISTOR 10Ω, ¼W, 10%	011120
R15	RESISTOR 22K, 2W, 10%	011373
R16	RESISTOR 4.7K, 2W, 10%	011365
R17	RESISTOR 3.92K, ¼W, 1%	411381
T1	PULSE TRANSFORMER	019521
Δ VR1,VR2	ZENER DIODE 6.8V	057113

DE6352

Fig. A2(b)–P.A.T. & P.E.T. driver card assemblies (444870 & 444871).



444859 - OVERHEAT DRIVER



445280 & 444858 - ON-OFF DRIVERS

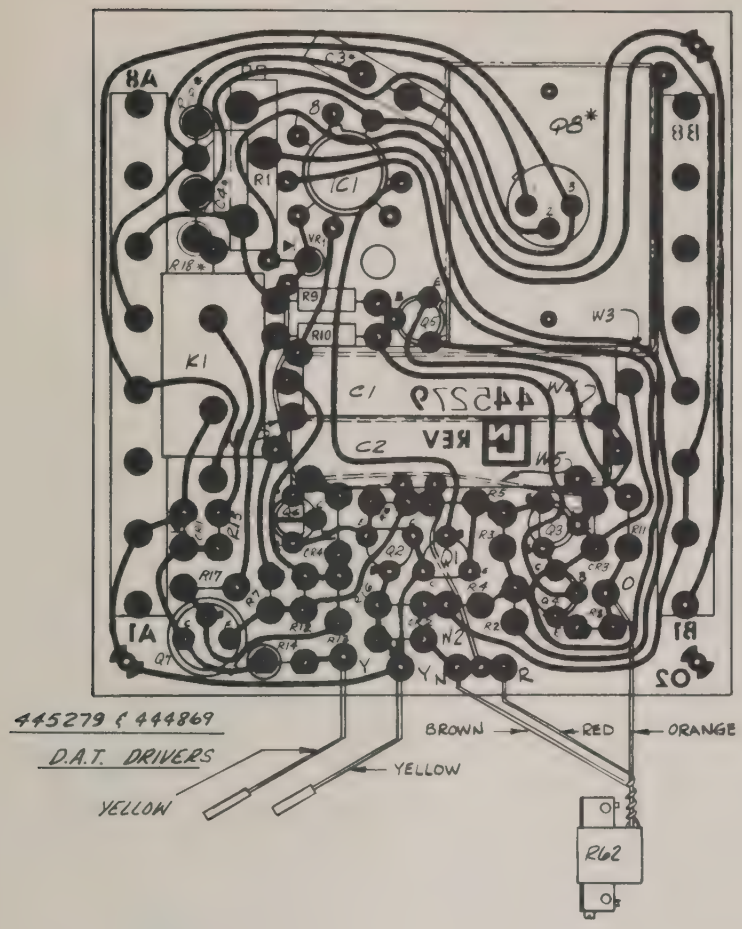
SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 1UF, 50V	023415
C2	CAPACITOR 0.01UF, 100V	023451
△ CR1, CR2	DIODE IN914A	188056
△ K1	RELAY DPDT	036573
△ Q1	TRANSISTOR 2N2219A	188299
R2	RESISTOR 4.7K, ¼W, 10%	311112
R4	RESISTOR 47K, ¼W, 10%	311111
R5	RESISTOR 220Ω, ¼W, 10%	011136
R6	RESISTOR 150Ω, ¼W, 10%	011134
R7	RESISTOR 22Ω, ¼W, 10%	311384

SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 1UF, 50V	023415
C2	CAPACITOR 0.01UF, 100V	023451
C3*	CAPACITOR 0.005UF, 500V	023433
CR2	DIODE IN914A	188056
C4	CAPACITOR 0.005UF, 100V	023291
△K1	REED SWITCH	032621
△Q1	TRANSISTOR 2N3417	188182
△Q2	TRANSISTOR 2N3053	188173
△Q3*	TRIAC RCA 40536	057174
R1	RESISTOR 12K, ¼W, 10%	311259
R2	RESISTOR 22K, ¼W, 10%	011771
R3	RESISTOR 4.7K, ¼W, 10%	011152
R4	RESISTOR 4.7K, ¼W, 10%	311112
R5	RESISTOR 47Ω, ¼W, 10%	311334
R6, R7	RESISTOR 2.2K, ¼W, 10%	011927
R8	RESISTOR 150Ω, ¼W, 10%	011134
R9*	RESISTOR 33K, ¼W, 10%	011150
R10*	RESISTOR 100Ω, ¼W, 10%	011132

* COMPONENTS NOT FURNISHED ON 444858 ON/OFF DRIVER.
JUMPERS ADDED: W1 - REPLACES R9
W2 - PINS 1 & 2 OF Q3

CE6353

Fig. A2(c)–Overheat and ON-OFF driver assemblies (444859, 444858 & 445280).

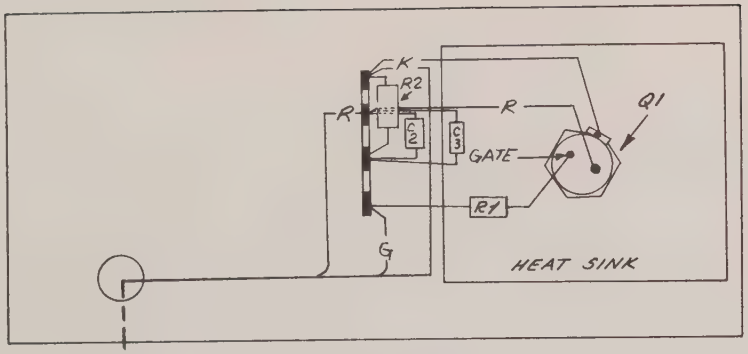


SYMBOL	DESCRIPTION	PART NO.
C1, C2	CAPACITOR 23UF, 10V	023677
C3*	CAPACITOR 0.001UF, 600V	023138
C4*	CAPACITOR 0.005UF, 100V	023291
△CR1,CR2,CR3,CR4	DIODE IN914A	188056
△IC1	INTEGRATED CIRCUIT μA741C	193207
△K1	RELAY	032621
△Q1, Q2	TRANSISTOR 2N6011	188352
△Q3, Q6	TRANSISTOR 2N5308	188282
△Q4, Q5	TRANSISTOR NS1683	188244
△Q7	TRANSISTOR 2N4037	188243
△Q8*	TRIAC RCA 40536	057174
R1	POTENTIOMETER 10K, ½W, 10%	013334
R2,R3,R4	RESISTOR 20K, ¼W, 1%	311233
R5,R6,R16	RESISTOR 10K, ¼W, 10%	011773
R7	RESISTOR 1K, ¼W, 10%	011934
R8, R11	RESISTOR 5.62K, ¼W, 1%	411399
R9	RESISTOR 124Ω, ¼W, 1%	411146
R10	RESISTOR 1.5K, ¼W, 1%	311895
R14	RESISTOR 150Ω, ¼W, 10%	011134
R15	RESISTOR 2.2K, ¼W, 10%	011927
R17	RESISTOR 7.5K, ¼W, 1%	311920
R18*	RESISTOR 3.3K, ¼W, 10%	011150
R19*	RESISTOR 100Ω, ¼W, 10%	011132
R12, R13	RESISTOR 1K, ¼W, 1%	411158
R62	POTENTIOMETER ASSEMBLY	013651
VR1	ZENER DIODE 1N758A	188126

* COMPONENTS NOT FURNISHED ON 444869 D.A.T. DRIVER.
JUMPER W6 ADDED BETWEEN R18-K1 JUNCTION & R19-A5 JUNCTION.

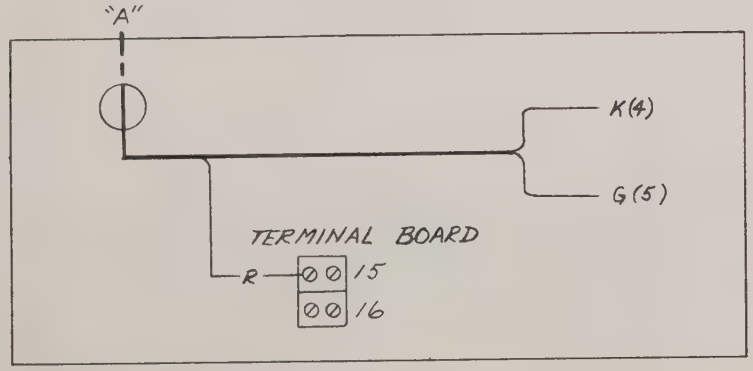
CE6354

Fig. A2(d)–D.A.T. driver card assemblies (444869 & 445279).



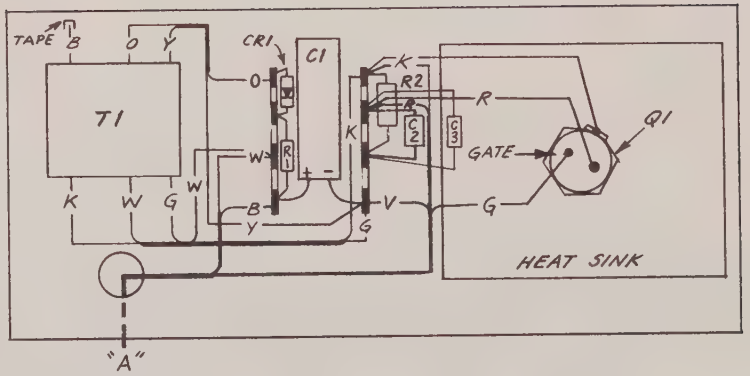
"A"

WIRING DIAGRAM

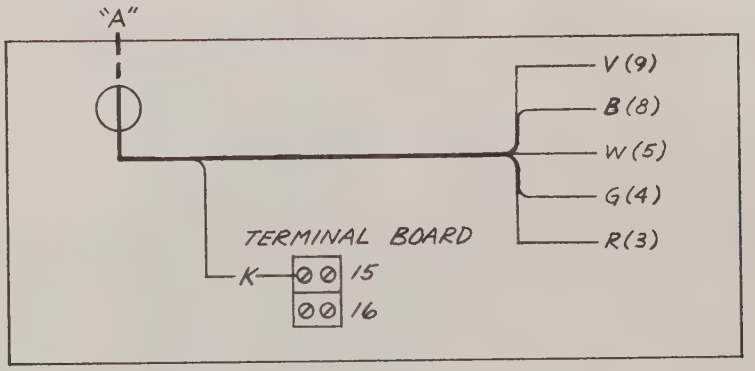


173071 - ON-OFF TRIAC

SYMBOL	DESCRIPTION	PART NO.
C2, C3	CAPACITOR 0.05UF, 500V	023433
△ Q1	TRIAC	057248
R1	RESISTOR 1K, ½W, 10%	011144
R2	RESISTOR 100Ω, ½W, 10%	011132
	HEAT SINK	190090



"A"

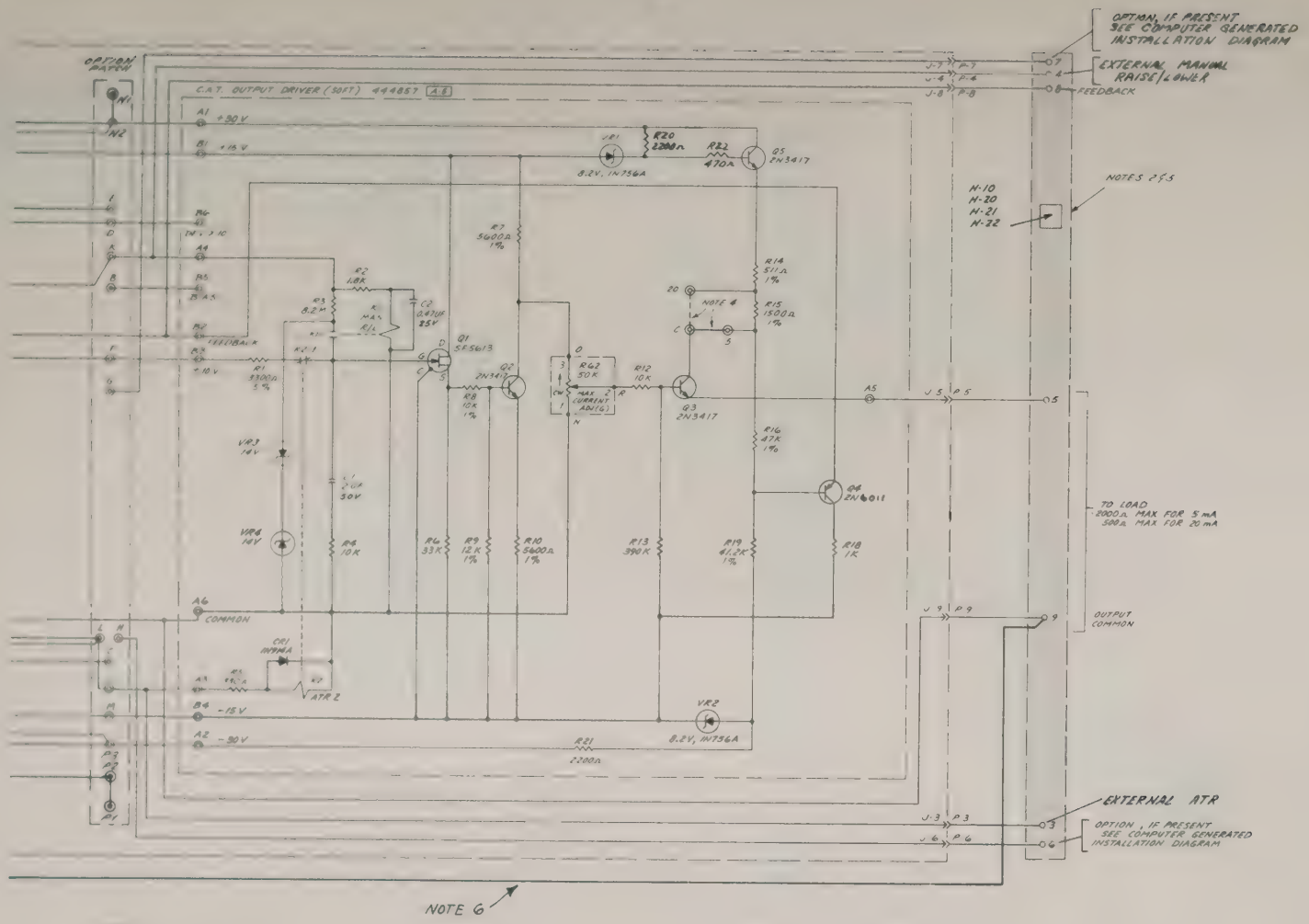


173072 - P.E.T. TRIAC

SYMBOL	DESCRIPTION	PART NO.
△ C1	CAPACITOR 100UF, 40V	023690
C2, C3	CAPACITOR 0.05UF, 500V	023433
△ CR1	DIODE	057134
△ Q1	TRIAC	057248
R1	RESISTOR 10K, ¼W, 10%	011773
R2	RESISTOR 100Ω, ½W, 10%	011132
△ T1	TRANSFORMER	019424
	HEAT SINK	190090

CE6355

Fig. A2(e)—ON-OFF and P.E.T. triac assemblies (173071 & 173072).



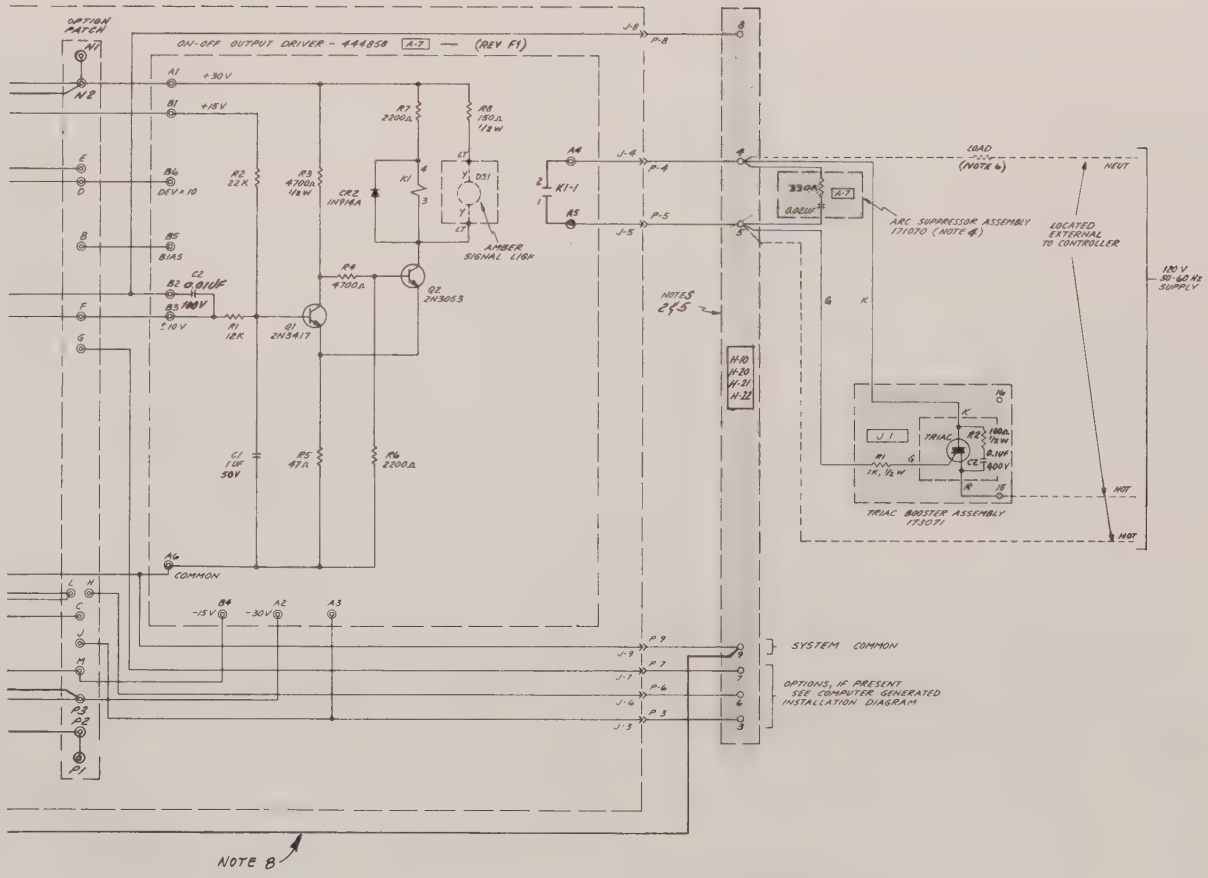
NOTES:

1. UNLESS OTHERWISE INDICATED:
   a. ALL RESISTORS ARE ¼ WATT.
   b. ALL RESISTORS ARE ±1%.
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. OUTPUT CURRENT SHOWN FOR 5 mA. FOR 20 mA REMOVE JUMPER BETWEEN C & 5 AND RECONNECT BETWEEN C & 20 AS SHOWN DOTTED.
5. TO COMPLETE SCHEMATIC WIRING AND FOR CATALOG SYSTEM EXPLANATION SEE DWG. D-D-2567-70 OR D-D-2567-80.
6. CONNECTION USED ON ELECTROMAX III ONLY, WITH COMPENSATOR PC CARD 445089, 444875 (REV. 4).

MAIN P.C. CARD CONNECTION:
RG0 – 1.33K – 310915 – STUDS D2 TO D4.

AE6361

Fig. A2(f)–C.A.T. (soft) driver card circuit (444857).



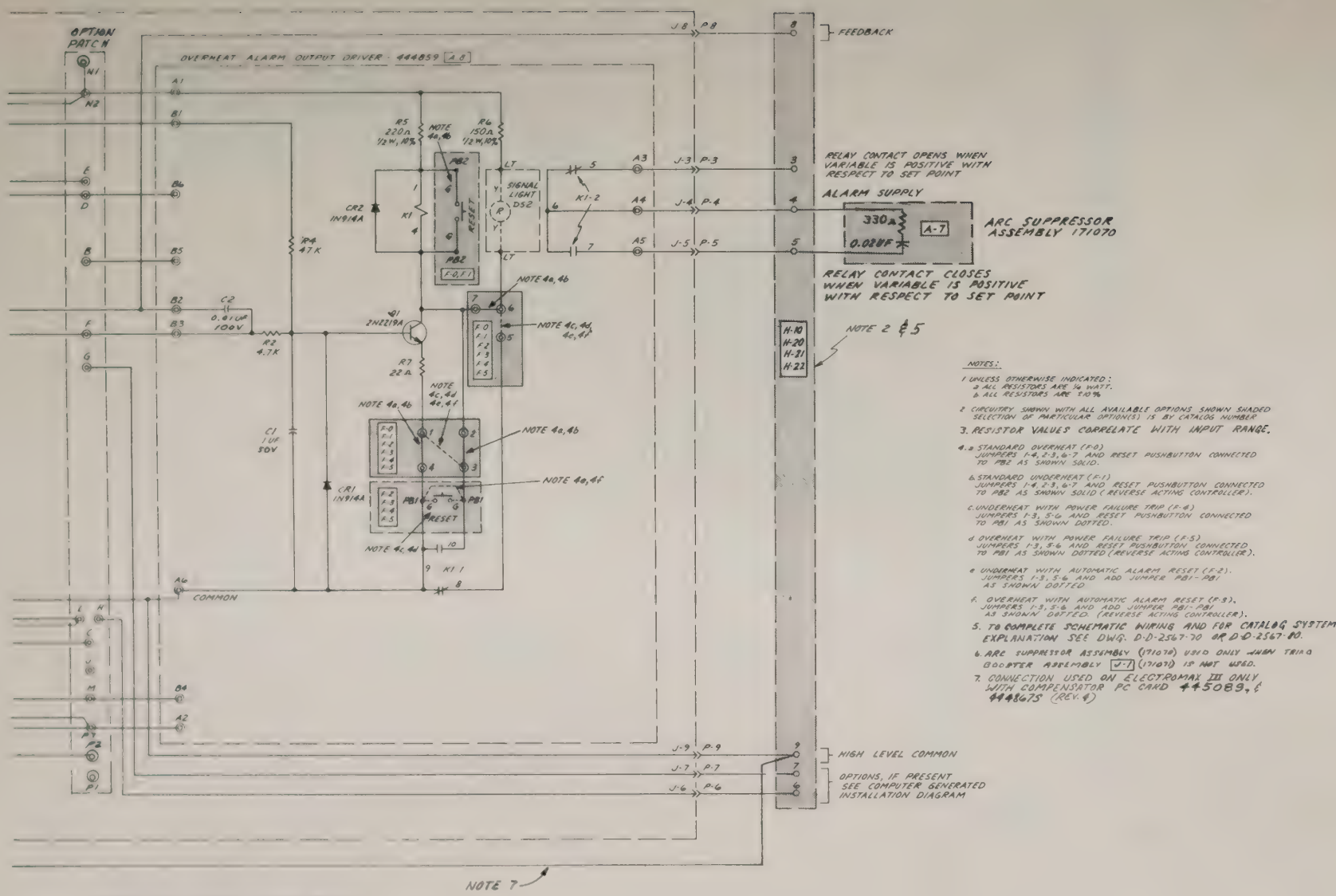
NOTES:

1. UNLESS OTHERWISE INDICATED
   a. ALL RESISTORS ARE 1/4 WATT.
   b. ALL RESISTORS ARE ± 10%.
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. ARC SUPPRESSOR ASSEMBLY (171070) USED WHEN TRIAC BOOSTER ASSEMBLY J-1 (173071) IS NOT USED.
5. TO COMPLETE SCHEMATIC WIRING AND CATALOG SYSTEM EXPLANATION SEE DWG. D-D-2567-70 OR D-D-2567-80.
6. LOAD - 10W MAX. WITHOUT TRIAC BOOSTER ASSEMBLY - 173071.
   LOAD - 10W MIN. TO 1KW MAX. WITH TRIAC BOOSTER ASSEMBLY - 173071.
   INDUCTIVE LOADS MUST BE SHUNTED WITH 1.0UF, 400V CAPACITOR AND 100Ω, 1/2W SERIES RESISTANCE, TO AVOID EXCESS VOLTAGE ACROSS THE TRIAC BOOSTER ASSEMBLY - 173071.
7. INTERNAL TRIAC RATED AT 1AMP (120VA), 130V MAX. FOR AC SWITCHING ONLY. FOR DC SWITCHING, AN AUXILIARY RELAY MUST BE USED. DO NOT USE THIS OPTION WITH TRIAC BOOSTER ASSEMBLY - 173071.
8. CONNECTION FOR COMPENSATOR PC CARD 445089, & 444875 (REV. 4) (ELECTROMAX III ONLY).
9. LOAD - 10W MIN. - 120W MAX. - 1A MAX. - 120V NOM. (130V MAX.).

MAIN P.C. CARD CONNECTION:
R48 (ELECTROMAX III) - 100K - 311781 - STUDS D2 TO D7.
R48 (ELECTROMAX IV) - 15K - 311779 - STUDS D2 TO D7.

AE6362

Fig. A2(g)—ON-OFF driver card circuit (444858).


OPTION PATCH
OVERHEAT ALARM OUTPUT DRIVER - 444859
FEEDBACK
RELAY CONTACT OPENS WHEN VARIABLE IS POSITIVE WITH RESPECT TO SET POINT
ALARM SUPPLY
330Ω
0.03MF
A-7
ARC SUPPRESSOR ASSEMBLY 171070
RELAY CONTACT CLOSES WHEN VARIABLE IS POSITIVE WITH RESPECT TO SET POINT
NOTE 2 & 5
HIGH LEVEL COMMON
OPTIONS, IF PRESENT SEE COMPUTER GENERATED INSTALLATION DIAGRAM
COMMON
SIGNAL LIGHT DS2
RESET
CR2 1N914A
CR1 1N914A
Q1 2N2219A
R1 4.7K
R2 4.7K
R4 47K
R5 220Ω 1/2W, 10%
R6 150Ω 1/2W, 10%
R7 22Ω
C1 1UF 50V
C2 0.01UF 100V
NOTE 7
NOTES:
1 UNLESS OTHERWISE INDICATED:
a ALL RESISTORS ARE ¼ WATT.
b ALL RESISTORS ARE ±10%
2 CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. a STANDARD OVERHEAT (F-0) JUMPERS 1-4, 2-3, 6-7 AND RESET PUSHBUTTON CONNECTED TO PB2 AS SHOWN SOLID.
b. STANDARD UNDERHEAT (F-1) JUMPERS 1-4, 2-3, 6-7 AND RESET PUSHBUTTON CONNECTED TO PB2 AS SHOWN SOLID (REVERSE ACTING CONTROLLER).
c. UNDERHEAT WITH POWER FAILURE TRIP (F-4) JUMPERS 1-3, 5-6 AND RESET PUSHBUTTON CONNECTED TO PB1 AS SHOWN DOTTED.
d OVERHEAT WITH POWER FAILURE TRIP (F-5) JUMPERS 1-3, 5-6 AND RESET PUSHBUTTON CONNECTED TO PB1 AS SHOWN DOTTED (REVERSE ACTING CONTROLLER).
e UNDERHEAT WITH AUTOMATIC ALARM RESET (F-2). JUMPERS 1-3, 5-6 AND ADD JUMPER PB1-PB1 AS SHOWN DOTTED
f. OVERHEAT WITH AUTOMATIC ALARM RESET (F-3). JUMPERS 1-3, 5-6 AND ADD JUMPER PB1-PB1 AS SHOWN DOTTED. (REVERSE ACTING CONTROLLER).
5. TO COMPLETE SCHEMATIC WIRING AND FOR CATALOG SYSTEM EXPLANATION SEE DWG. D-D-2567-70 OR D-D-2567-80.
6. ARC SUPPRESSOR ASSEMBLY (171070) USED ONLY WHEN TRIAC BOOSTER ASSEMBLY J-7 (171071) IS NOT USED.
7. CONNECTION USED ON ELECTROMAX III ONLY WITH COMPENSATOR PC CARD 445089, & 444675 (REV. 4)

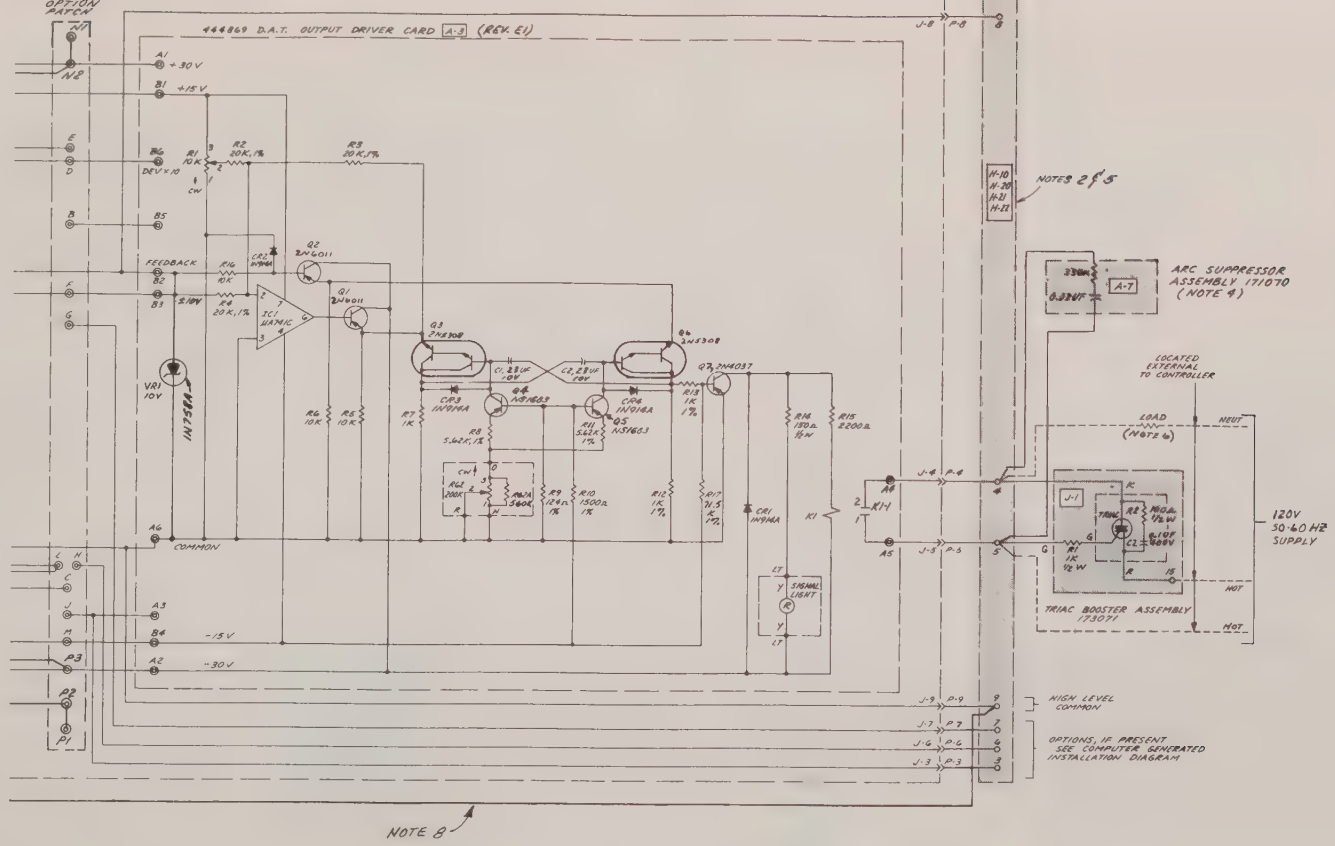
MAIN P.C. CARD CONNECTION:

R48 (ELECTROMAX III) - 100K - 311781 - STUDS D2 TO D7

R48 (ELECTROMAX IV) - 15K - 311779 - STUDS D2 TO D7

AE6363

Fig. A2(h)—Overheat alarm driver card circuit (444859).



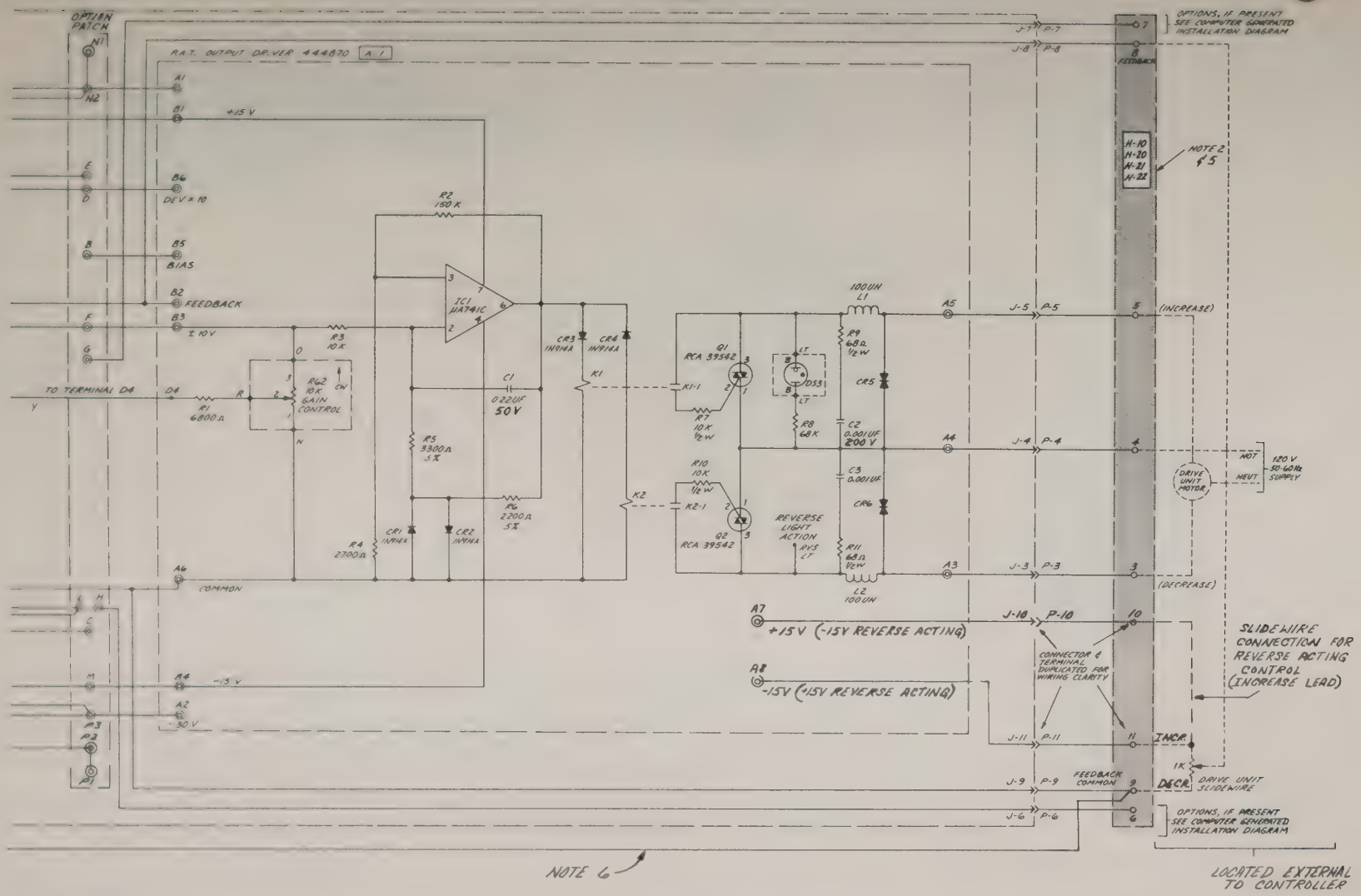
NOTES:

1. UNLESS OTHERWISE INDICATED:
   a. ALL RESISTORS ARE 1/4 WATT.
   b. ALL RESISTORS ARE ± 10%.
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. ARC SUPPRESSOR ASSEMBLY (171070) USED WHEN TRIAC BOOSTER ASSEMBLY J-1 (173071) IS NOT USED.
5. TO COMPLETE SCHEMATIC WIRING AND CATALOG SYSTEM EXPLANATION SEE DWG. D-D-2567-70 OR D-D-2567-80.
6. LOAD - 10W MAX. WITHOUT TRIAC BOOSTER ASSEMBLY - 173071. LOAD - 10W MIN. TO 1KW MAX. WITH TRIAC BOOSTER ASSEMBLY - 173071. INDUCTIVE LOADS MUST BE SHUNTED WITH 1.0UF, 400V CAPACITOR AND 100Ω, 1/2W SERIES RESISTANCE, TO AVOID EXCESS VOLTAGE ACROSS THE TRIAC BOOSTER ASSEMBLY - 173071.
7. INTERNAL TRIAC RATED AT 1AMP (120VA), 130V MAX. FOR AC SWITCHING ONLY. FOR DC SWITCHING, AN AUXILIARY RELAY MUST BE USED. DO NOT USE THIS OPTION WITH TRIAC BOOSTER ASSEMBLY - 173071.
8. CONNECTION FOR COMPENSATOR PC CARD 445089, # 444867S (REV. 4) (ELECTROMAX III ONLY).
9. LOAD - 10W MIN. - 120W MAX. - 1A MAX. - 120V NOM. (130V MAX.).

MAIN P.C. CARD CONNECTION:
R60-2K-310916 - STUDS D2 TO D4

AE6364

Fig. A2(i)–D.A.T. driver card circuit (444869).



NOTES:

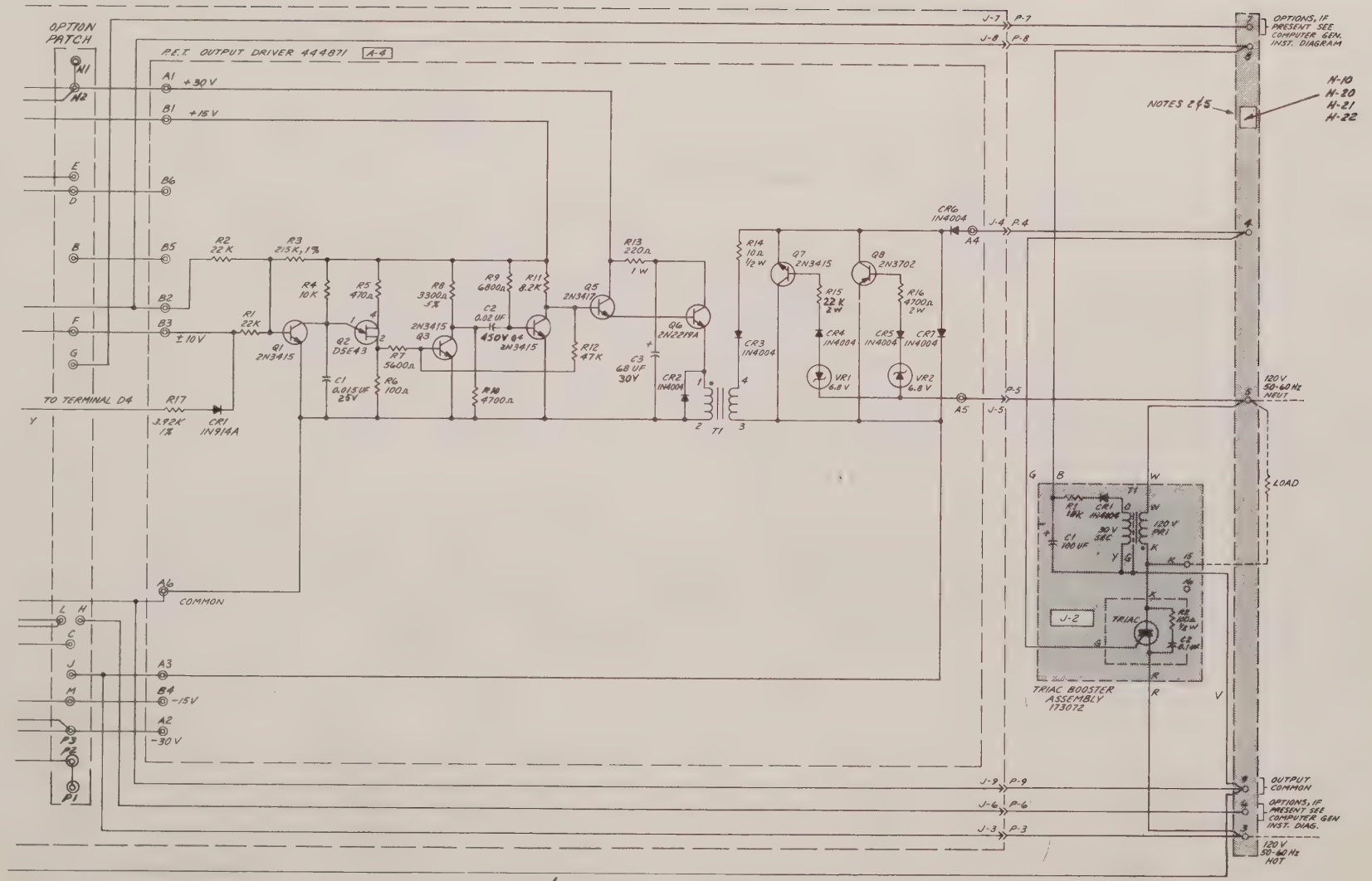
1. UNLESS OTHERWISE INDICATED:
   a ALL RESISTORS ARE ⅛ WATT
   b ALL RESISTORS ARE ± 10%.
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
5. TO COMPLETE SCHEMATIC WIRING AND FOR CATALOG SYSTEM EXPLANATION SEE DWG. D-0-2567-70.
6. CONNECTION USED ON ELECTROMAX III ONLY WITH COMPENSATOR P.C. CARD 445089, & 444873 (REV. 4).

MAIN P.C. CARD CONNECTION:
R60 – 6.19 K – 310914 – STUDS D2 TO D4.

AE6365

AE6365

Fig. A2(j)–P.A.T. driver card circuit (444870).



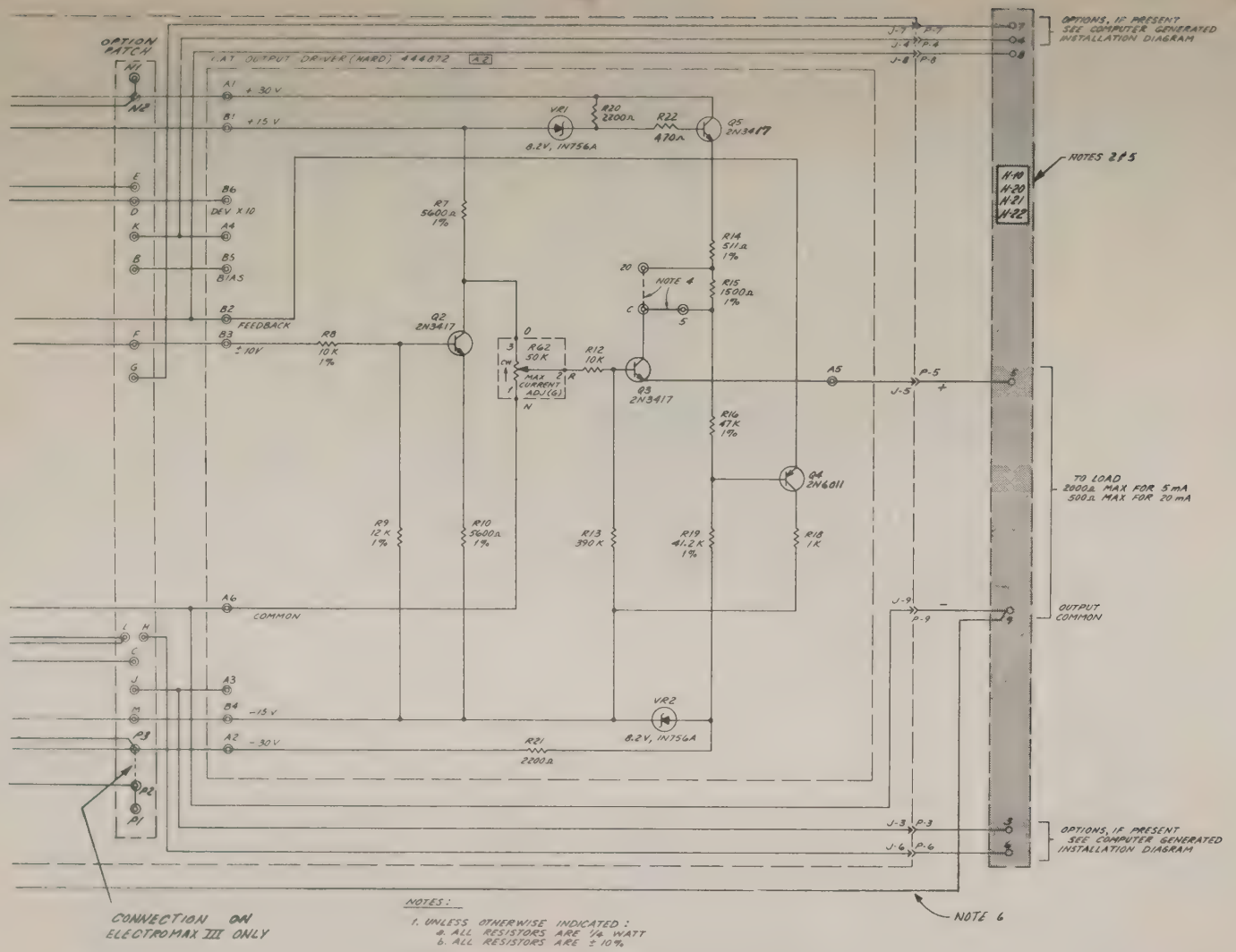
NOTES:

1. UNLESS OTHERWISE INDICATED:
   a. ALL RESISTORS ARE ¼ WATT
   b. ALL RESISTORS ARE ±10%
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE
5. TO COMPLETE SCHEMATIC WIRING AND FOR CATALOG SYSTEM EXPLANATION SEE DWG. D-D-2567-70 OR D-D-2567-80
6. CONNECTION USED ON ELECTROMAX III ONLY WITH COMPENSATOR PC CARD 445089, 444867S (REV. 4).

MAIN P.C. CARD CONNECTION:
R48 - 15K - 311779 - STUDS D2 TO D7.
(IN PLACE OF OUTPUT METER)

AE6366

Fig. A2(k)—P.E.T. driver card circuit (444871).



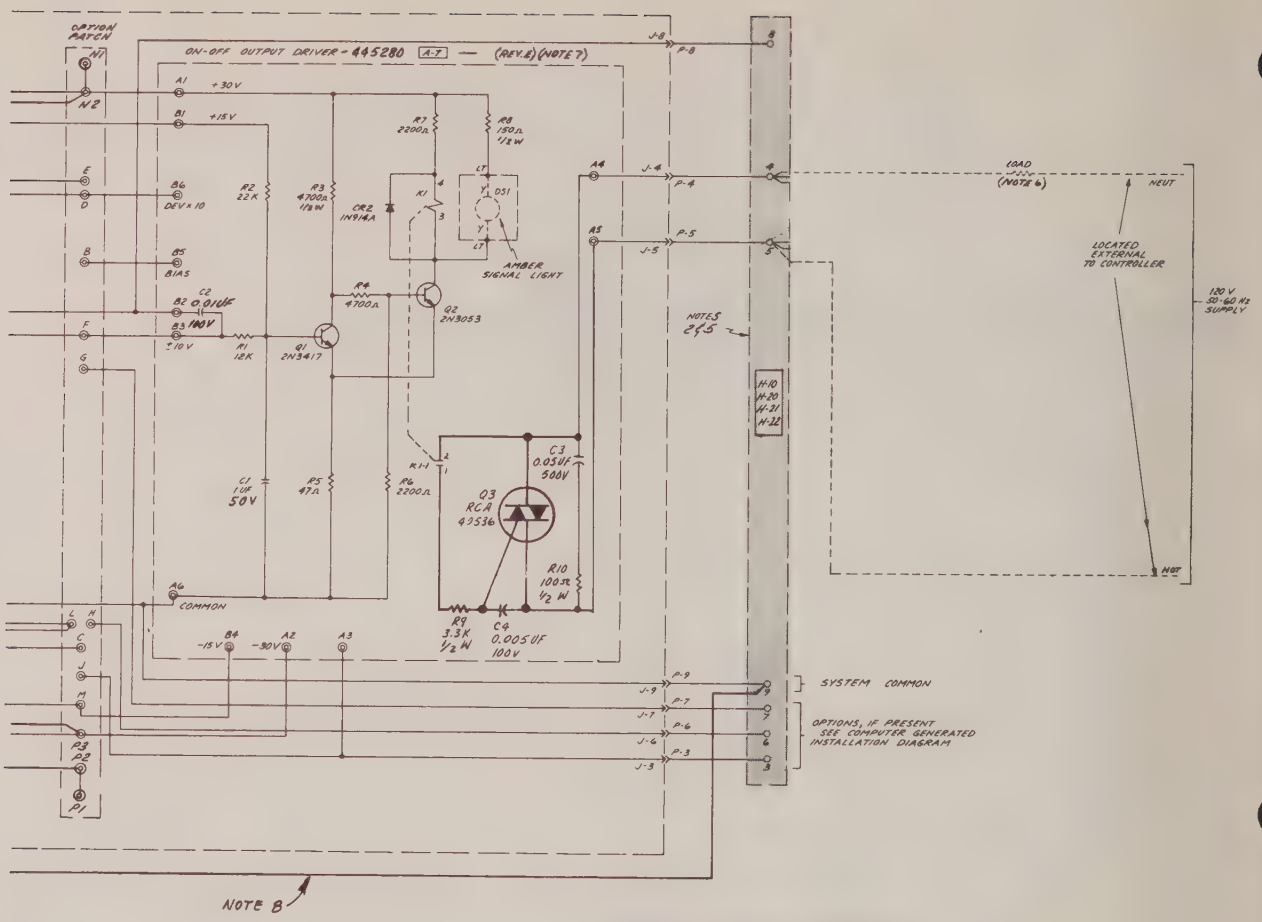
MAIN P.C. CARD CONNECTION:
R60-1.33K-310915 - STUDS D2 TO D4.

NOTES:

1. UNLESS OTHERWISE INDICATED:
   a. ALL RESISTORS ARE 1/4 WATT
   b. ALL RESISTORS ARE ± 10%
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. OUTPUT CURRENT SHOWN FOR 5 mA. FOR 20 mA REMOVE JUMPER BETWEEN C & 5 AND RECONNECT BETWEEN C & 20 AS SHOWN DOTTED.
5. TO COMPLETE SCHEMATIC WIRING AND FOR CATALOG SYSTEM EXPLANATION SEE DWG. D-D-2567-70 OR D-D 2567-80.
6. CONNECTION USED ON ELECTROMAX III ONLY WITH COMPENSATOR PC CARD 445089,1 444873 (REV. 4).

AE6367

Fig. A2(1)–C.A.T. (hard) driver card circuit (444872).



MAIN PC CARD CONNECTION

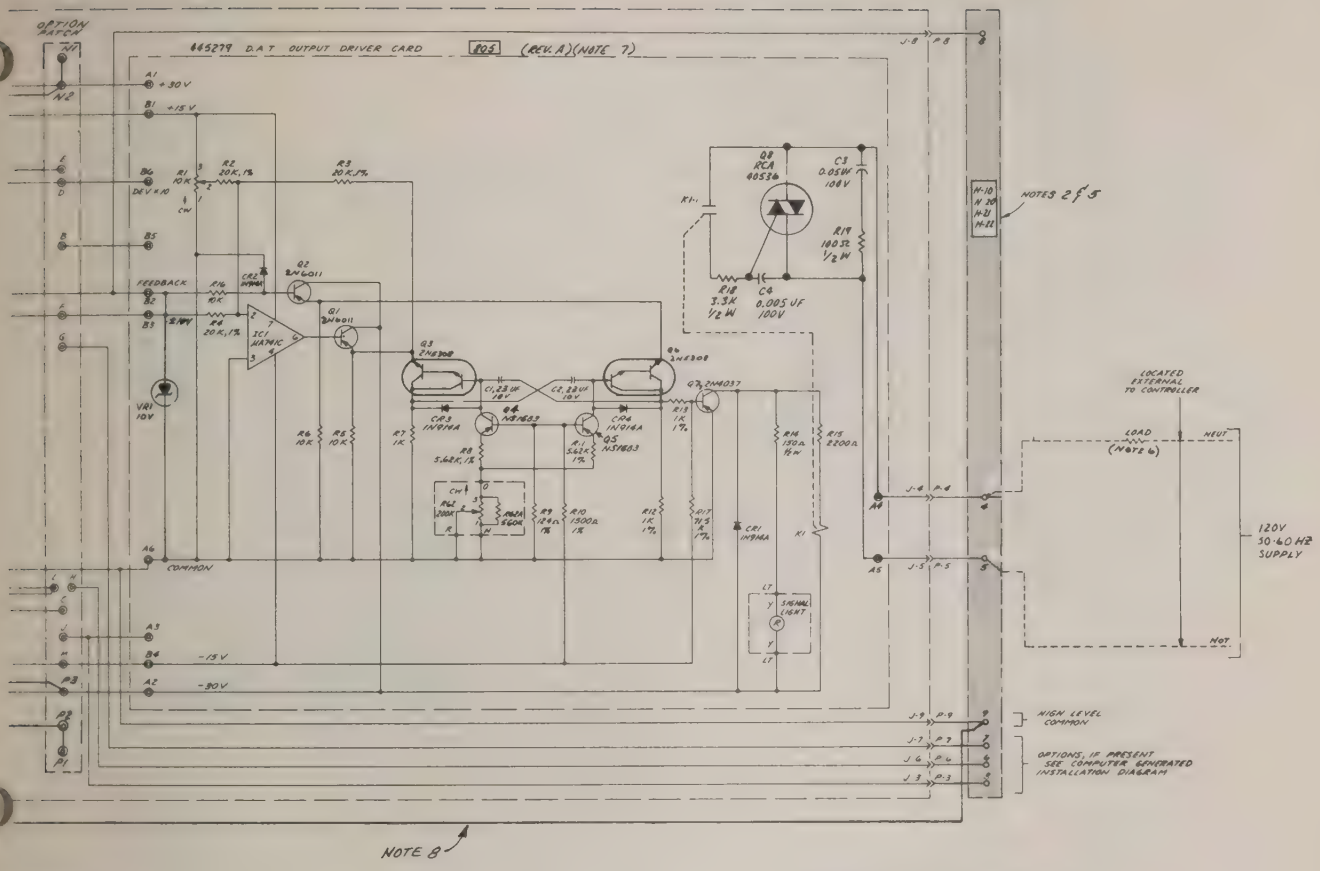
(ELECTROMAX III) R48-100K - 311781 - STUDS D2 TO D7
(ELECTROMAX IV) R48-15K - 311779 - STUDS D2 TO D7

NOTES:

1. UNLESS OTHERWISE INDICATED
   a. ALL RESISTORS ARE ¼ WATT.
   b. ALL RESISTORS ARE ± 10%.
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. ARC SUPPRESSOR ASSEMBLY (171070) USED WHEN TRIAC BOOSTER ASSEMBLY J-1 (173071) IS NOT USED.
5. TO COMPLETE SCHEMATIC WIRING AND CATALOG SYSTEM EXPLANATION SEE DWG. D-D-2567-70 OR D-D-2567-80.
6. LOAD - 10W MAX. WITHOUT TRIAC BOOSTER ASSEMBLY - 173071. LOAD - 10W MIN. TO 1KW MAX. WITH TRIAC BOOSTER ASSEMBLY - 173071. INDUCTIVE LOADS MUST BE SHUNTED WITH 1.0UF, 400V CAPACITOR AND 100Ω, 1/2W SERIES RESISTANCE, TO AVOID EXCESS VOLTAGE ACROSS THE TRIAC BOOSTER ASSEMBLY - 173071.
7. INTERNAL TRIAC RATED AT 1AMP (120VA), 130V MAX. FOR AC SWITCHING ONLY. FOR DC SWITCHING, AN AUXILIARY RELAY MUST BE USED. DO NOT USE THIS OPTION WITH TRIAC BOOSTER ASSEMBLY - 173071.
8. CONNECTION FOR COMPENSATOR PC CARD 445089, & 444867S (REV. 4) (ELECTROMAX III ONLY).
9. LOAD - 10W MIN. - 120W MAX. - 1A MAX. - 120V NOM. (130V MAX.).

AE7105

Fig. A2(m)–ON-OFF driver card circuit (445280).



MAIN PC CARD CONNECTION

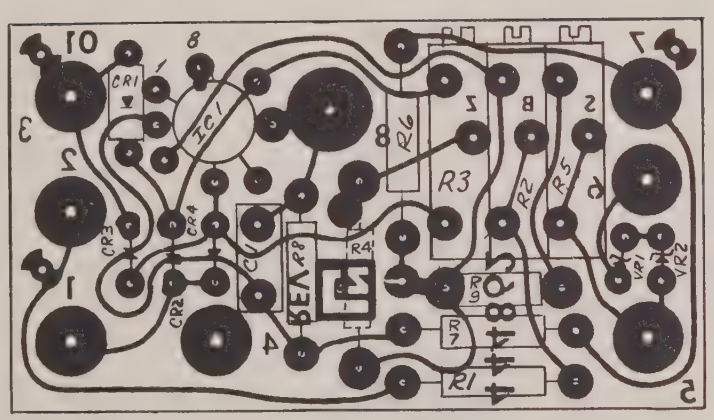
R60 - 2K - 310916 - STUDS D2 TO D4

NOTES:

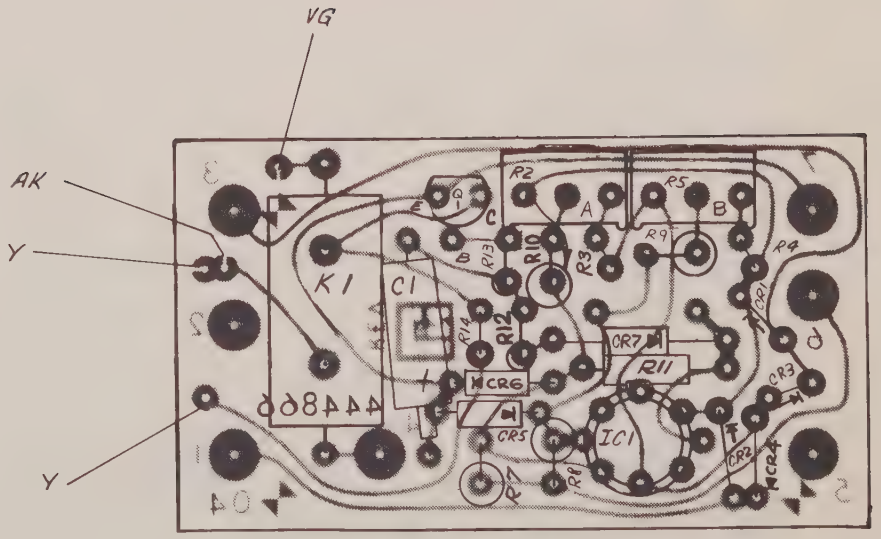
1. UNLESS OTHERWISE INDICATED:
   a. ALL RESISTORS ARE 1/4 WATT.
   b. ALL RESISTORS ARE ± 10%
2. CIRCUITRY SHOWN WITH ALL AVAILABLE OPTIONS SHOWN SHADED. SELECTION OF PARTICULAR OPTION(S) IS BY CATALOG NUMBER.
3. RESISTOR VALUES CORRELATE WITH INPUT RANGE.
4. ARC SUPPRESSOR ASSEMBLY (171070) USED WHEN TRIAC BOOSTER ASSEMBLY Y-1 (173071) IS NOT USED.
5. TO COMPLETE SCHEMATIC WIRING AND CATALOG SYSTEM EXPLANATION SEE DWG D-D-2567-70 OR D-D-2567-80.
6. LOAD - 10W MAX. WITHOUT TRIAC BOOSTER ASSEMBLY - 173071. LOAD - 10W MIN. TO 1KW MAX. WITH TRIAC BOOSTER ASSEMBLY - 173071. INDUCTIVE LOADS MUST BE SHUNTED WITH 1.0UF, 400V CAPACITOR AND 100Ω, 1/2W SERIES RESISTANCE, TO AVOID EXCESS VOLTAGE ACROSS THE TRIAC BOOSTER ASSEMBLY - 173071.
7. INTERNAL TRIAC RATED AT 1AMP (120VA), 130V MAX. FOR AC SWITCHING ONLY. FOR DC SWITCHING, AN AUXILIARY RELAY MUST BE USED. DO NOT USE THIS OPTION WITH TRIAC BOOSTER ASSEMBLY - 173071.
8. CONNECTION FOR COMPENSATOR PC CARD 445089, (444875 (REV. 4) (ELECTROMAX III ONLY).
9. LOAD - 10W MIN. - 120W MAX. - 1A MAX. - 120V NOM. (130V MAX.).

AE7106

Fig. A2(n)—D.A.T. driver card circuit (445279).



444862 INPUT/OUTPUT OPTION



444866 DEVIATION ALARM OPTION

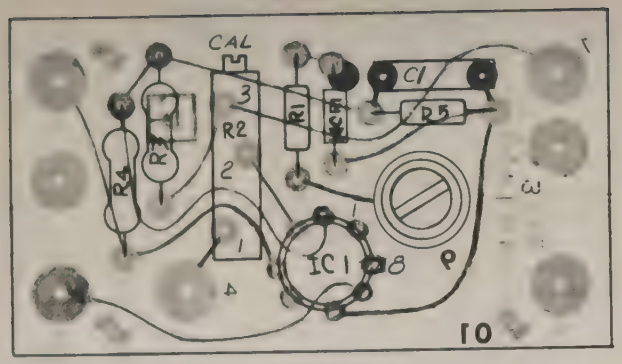
SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 0.001UF, 500V	023097
△ CR1,CR2,CR3,CR4	DIODE IN914A	188056
△ IC1	INTEGRATED CIRCUIT μA741C	193207
R1	RESISTOR 8.2K, ¼W, 1%	411403
R2,R3	POTENTIOMETER 50K, ¾W, 10%	013695
✱ R4		
R5	POTENTIOMETER 10K, ¾W, 10%	013678
R6,R7	RESISTOR 100Ω, ¼W, 1%	311787
R8	RESISTOR 13K, 1/8W, 1%	411436
R9	RESISTOR 562Ω, 1/8W, 1%	311863
△ VR1,VR2	ZENER DIODE 8.2V	057178

✱ MUST BE ORDERED SEPARATELY FROM OPTION CARD.

SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 22UF, 15V	023303
CR1,CR2,CR3,CR4, △ CR5,CR6,CR7	DIODE IN914A	188056
△ IC1	INTEGRATED CIRCUIT μA741C	193207
△ K1	RELAY	032621
△ Q1	TRANSISTOR 2N6011	188352
△ R2,R5	POTENTIOMETER 10K, 1W, 20%	013622
R3,R4	RESISTOR 4.87K, ¼W, 1%	311792
R7,R8	RESISTOR 158K, ¼W, 1%	311778
R9,R10	RESISTOR 499K, ¼W, 1%	311899
R11	RESISTOR 27M, ¼W, 10%	311801
R12,R13	RESISTOR 4.7K, ¼W, 10%	311112
R14	RESISTOR 100Ω, ¼W, 10%	011994

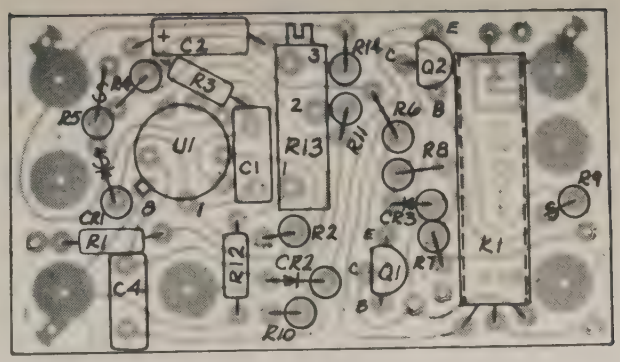
CE6356

Fig. A3(a)–Input/output and deviation alarm option card assemblies (444862 & 444866).



444865 APPROACH OPTION

SYMBOL	DESCRIPTION	PART NO.
C1	CAPACITOR 0.1 μF, 30V	023330
△ CR1	DIODE 1N914A	188056
△ IC1	INTEGRATED CIRCUIT μA741C	193207
R1	RESISTOR 47K, 1/4W, 10%	311111
R2	POTENTIOMETER 50K, 3/4W, 10%	013449
R3	RESISTOR 4.32K, 1/4W, 1%	411531
R4	RESISTOR 45K, 1/4W, 1%	311776
R5	RESISTOR 1M, 1/4W, 10%	011931



445258 DUAL CONTROL OPTION

SYMBOL	DESCRIPTION	PART NO.
R1,R3,R5	RESISTOR 10K, 1/4W, 10%	011773
R10,R11	RESISTOR 1M, 1/4W, 10%	011931
R2	RESISTOR 4.7K, 1/4W, 10%	311112
R4	RESISTOR 1K, 1/4W, 10%	011934
R6	RESISTOR 150Ω, 1/2W, 10%	011134
R7	RESISTOR 2.2K, 1/4W, 10%	011927
R9	RESISTOR 20K, 1/4W, 1%	311233
R12,R14	POTENTIOMETER 10K, 3/4W, 10%	013678
R13	RESISTOR 470Ω, 1/4W, 10%	011765
R8	CAPACITOR 0.005μF,100V, +70%, -30%	023291
C1,C4	CAPACITOR 0.82μF, 35V, 10%	023569
C2	DIODE 1N914A	188056
△ CR1,CR2	LEAD - YELLOW	337347
CR3	REED SWITCH	036658
K1	TRANSISTOR 2N3417	188182
△ Q1,Q2	INTEGRATED CIRCUIT 1458 (DUAL 741)	193021
△ U1		

AE6357

Fig. A3(b)–Approach and Dual control option card assemblies (444865 & 445258).

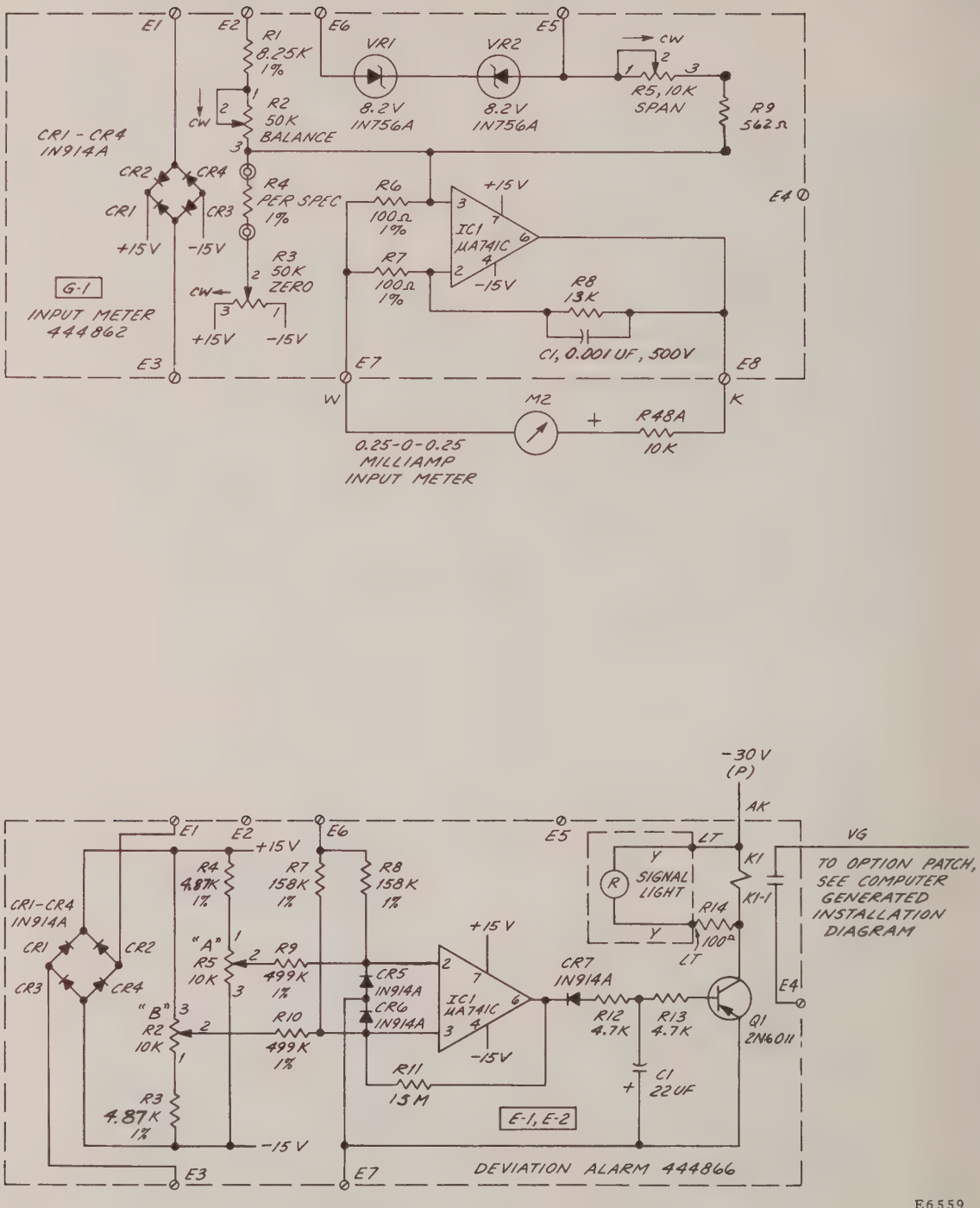


Fig. A3(c)–Input meter circuit (444862 & M2) and deviation alarm circuit (444866). See Fig. 6 for other combinations and Fig. A1(b) for connections to D&E studs.

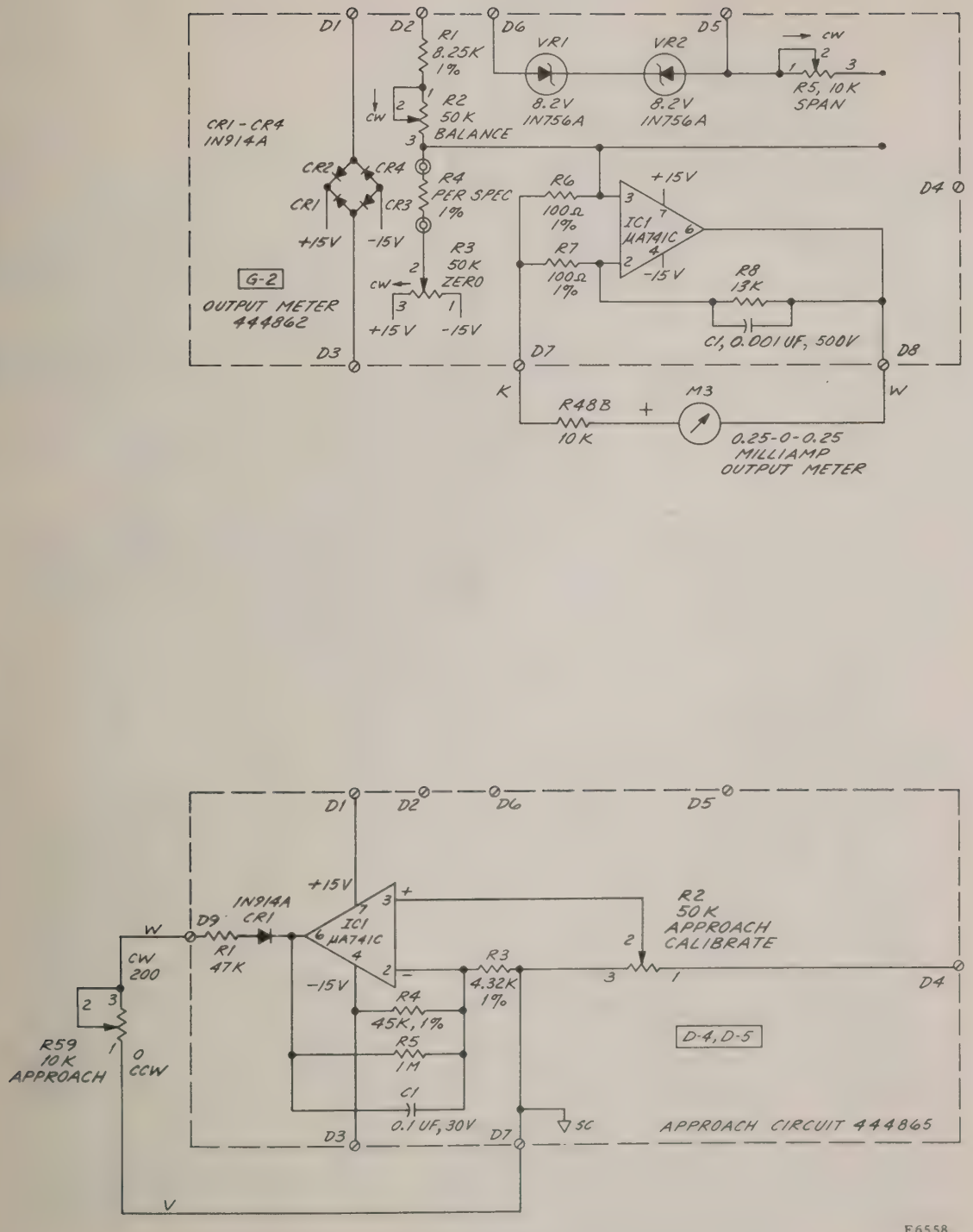
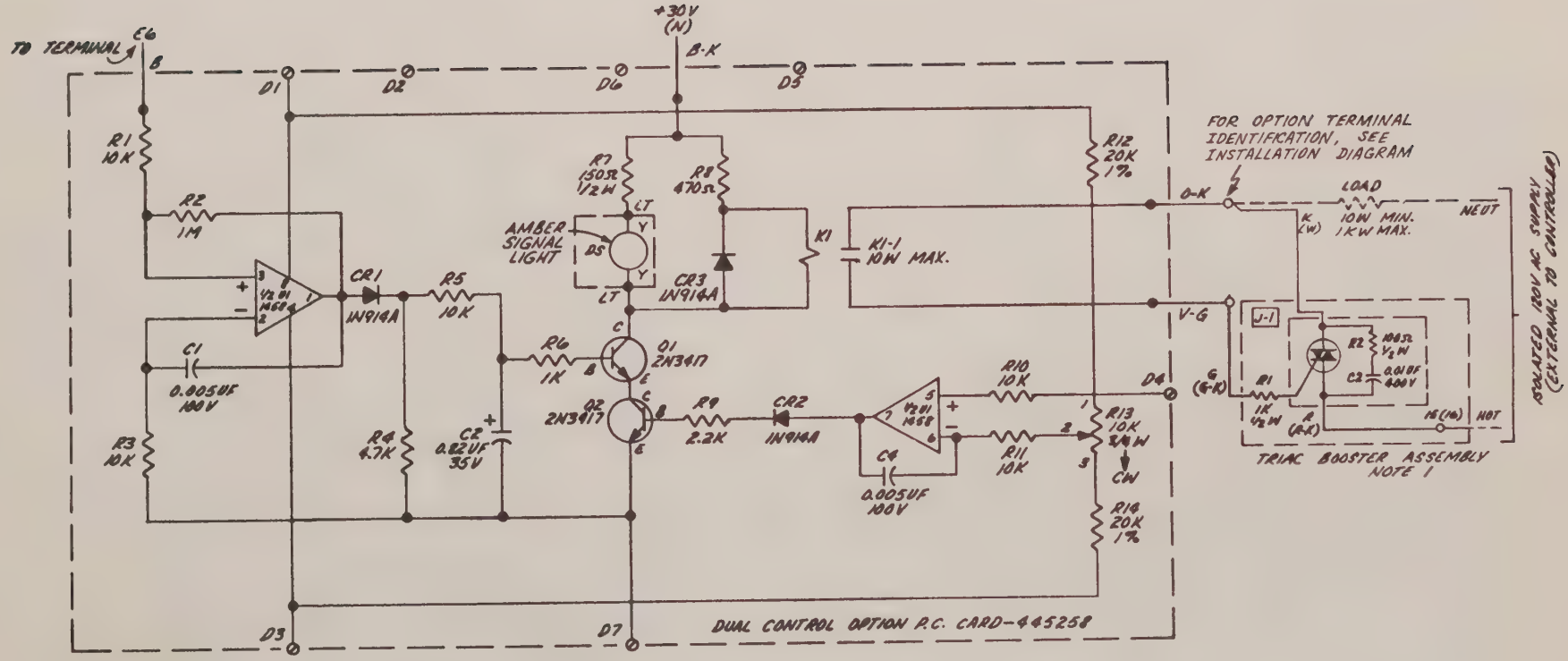


Fig. A3(d)—Output meter circuit (444862 & M3) and approach circuit (444865).

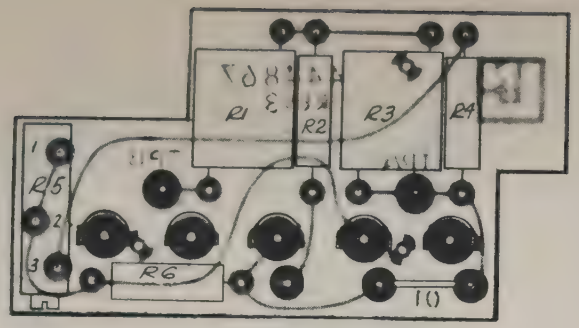


NOTES:

1. TRIAC BOOSTER IS CONNECTED AS SHOWN. REFER TO INSTALLATION DIAGRAM FOR SPECIFIC DETAILS.

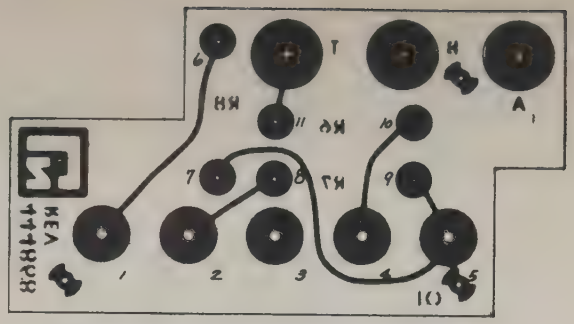
E7136

Fig. A3(e)–Dual control option card circuit (445258).

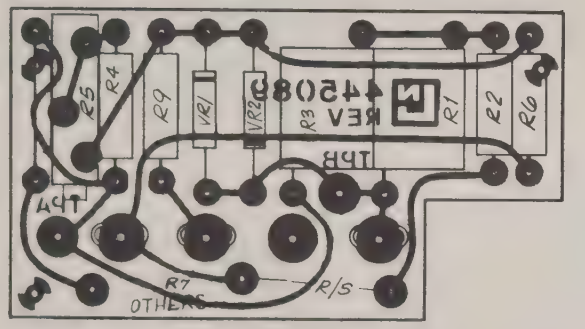


444867 THERMOCOUPLE COMPENSATOR

SYMBOL	DESCRIPTION	PART NO.
R1,R3	RESISTOR 200Ω, 1%	310776
R2	RESISTOR 39.2K, ¼W, 1%	411389
R4	RESISTOR 1.33K, ¼W, 1%	411377
R5	POTENTIOMETER 2K, ¾W, 10%	013677
R6	RESISTOR 63.4K, ¼W, 1%	411228

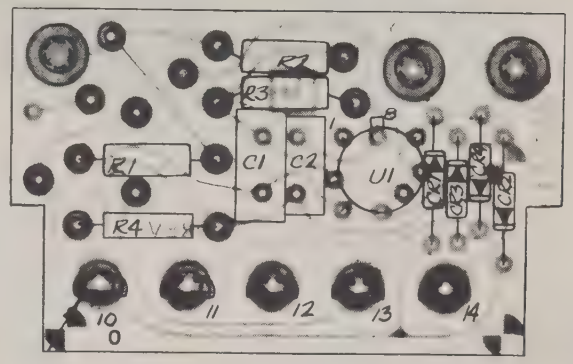


444868 THERMOHM COMPENSATOR



445089 THERMOCOUPLE COMPENSATOR

SYMBOL	DESCRIPTION	PART NO.
R1, R3	RESISTOR 200Ω, 1%	310776
R2	RESISTOR 41.2K, ¼W, 1%	311921
R4	RESISTOR 680Ω, ¼W, 1%	311768
R5	POTENTIOMETER 1K, ¾W, 10%	013677
R6	RESISTOR 45K, ¼W, 1%	311776
R9	RESISTOR 402Ω, ¼W, 1%	311152
△ VR1, VR2	ZENER DIODE 9.2V	057287

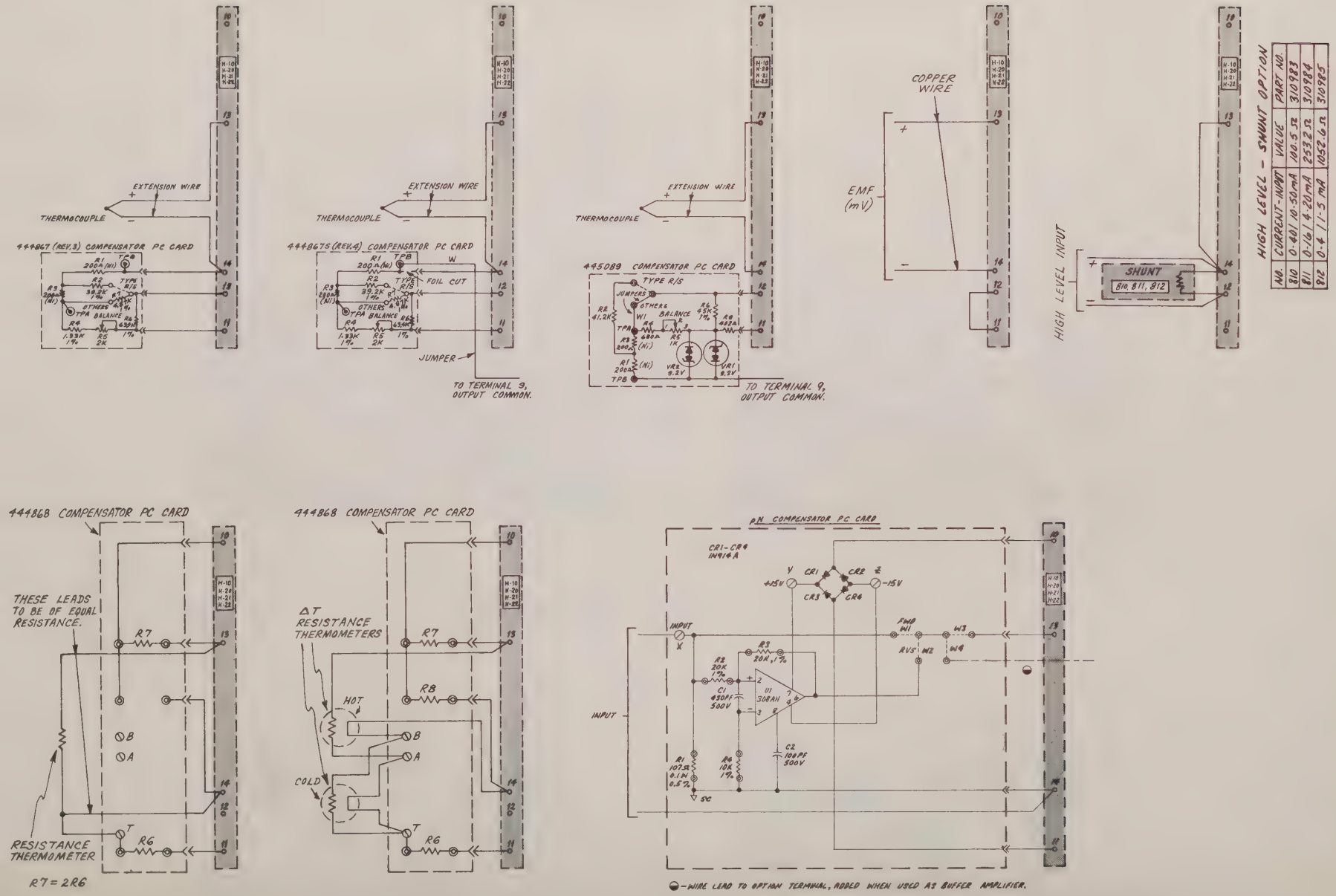


445259 pH INPUT CARD

SYMBOL	DESCRIPTION	PART NO.
R1	RESISTOR, 107Ω, 0.1W, 5%	311972
R2,R3	RESISTOR, 20K, ¼W, 1%	311780
R4	RESISTOR, 10K, ¼W, 1%	311785
C1	CAPACITOR, 430PF, 500V	023743
C2	CAPACITOR, 100UF, 500V	023596
△ CR1,CR2,CR3, CR4	DIODE IN914A	188056
△ U1	I.C. LM308AH	193201

AE6358

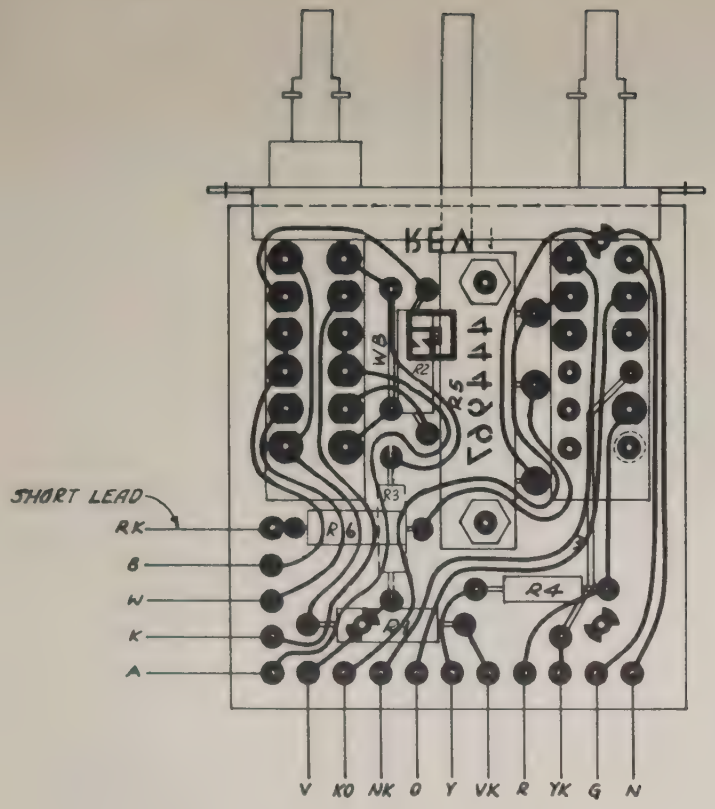
Fig. A4(a)—Thermocouple, Thermohm and pH compensator card assemblies (444867, 444868, 445089, and 445259).



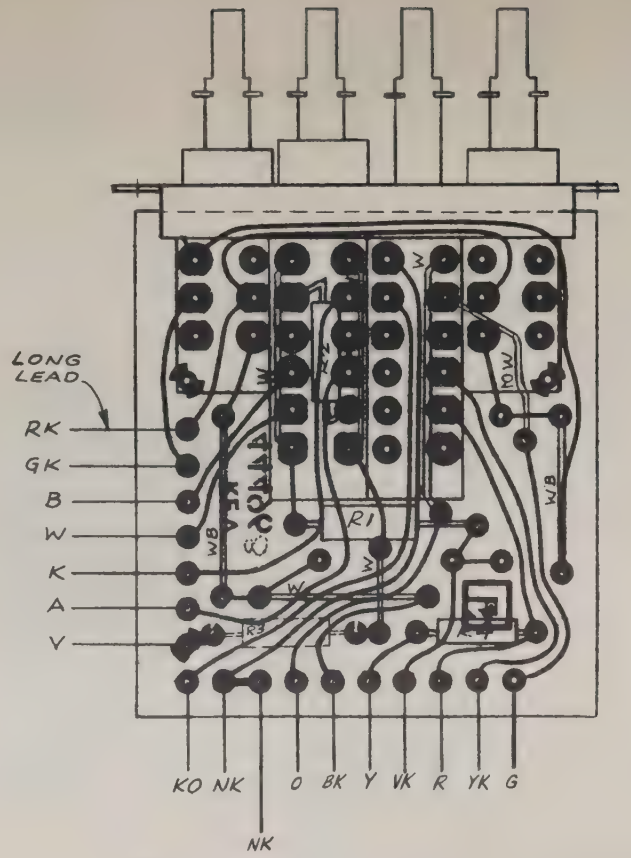
NO.	CURRENT-INPUT	VALUE	PART NO.
810	0-40 / 10-50mA	100.5 Ω	310983
811	0-16 / 4-20mA	253.2 Ω	310984
812	0-4 / 1-5 mA	1052.6 Ω	310985

CE7137

Fig. A4(b)–Input circuits.



444967 HARD MANUAL STATION



444968 C.A.T. (SOFT) MANUAL STATION

SYMBOL	DESCRIPTION	PART NO.
R1	RESISTOR 1.33K, ¼W, 1%	411377
R2	RESISTOR 1K, ¼W, 1%	411300
R4	RESISTOR 220Ω ¼W, 10%	311113
R5	POTENTIOMETER 10K	013218
R6	RESISTOR 1K, ¼W, 1%	411300
*R3		

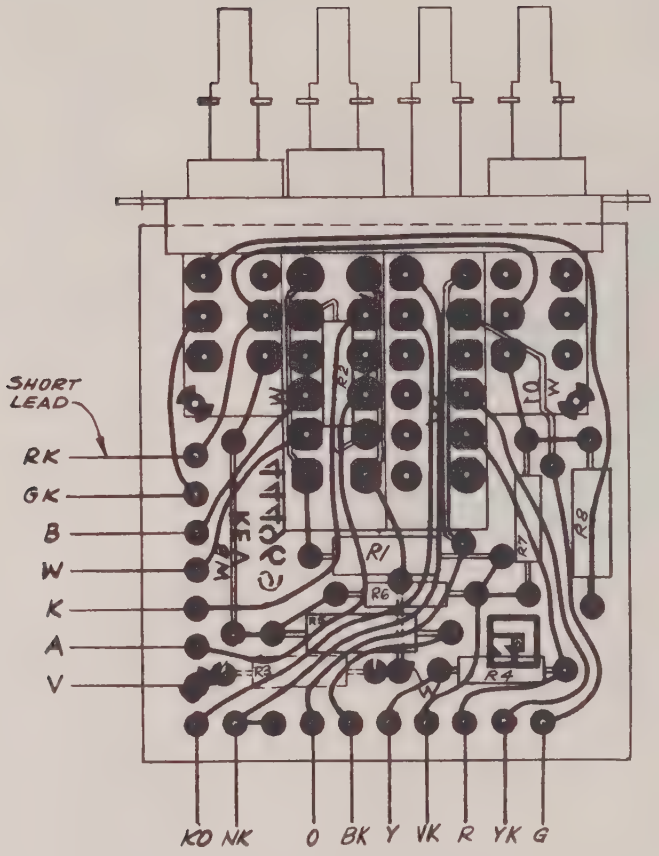
* MUST BE ORDERED SEPARATELY FROM STATION.

SYMBOL	DESCRIPTION	PART NO.
R1	RESISTOR 1.33K, ¼W, 1%	411377
R2	RESISTOR 1K, ¼W, 1%	411300
R4	RESISTOR 220Ω ¼W, 10%	311113
*R3		

* MUST BE ORDERED SEPARATELY FROM STATION.

CE6359

Fig. A5(a)–C.A.T. manual station card assemblies; 444967 Hard Manual Station (G3), and 444968 Soft Manual Station (G4).



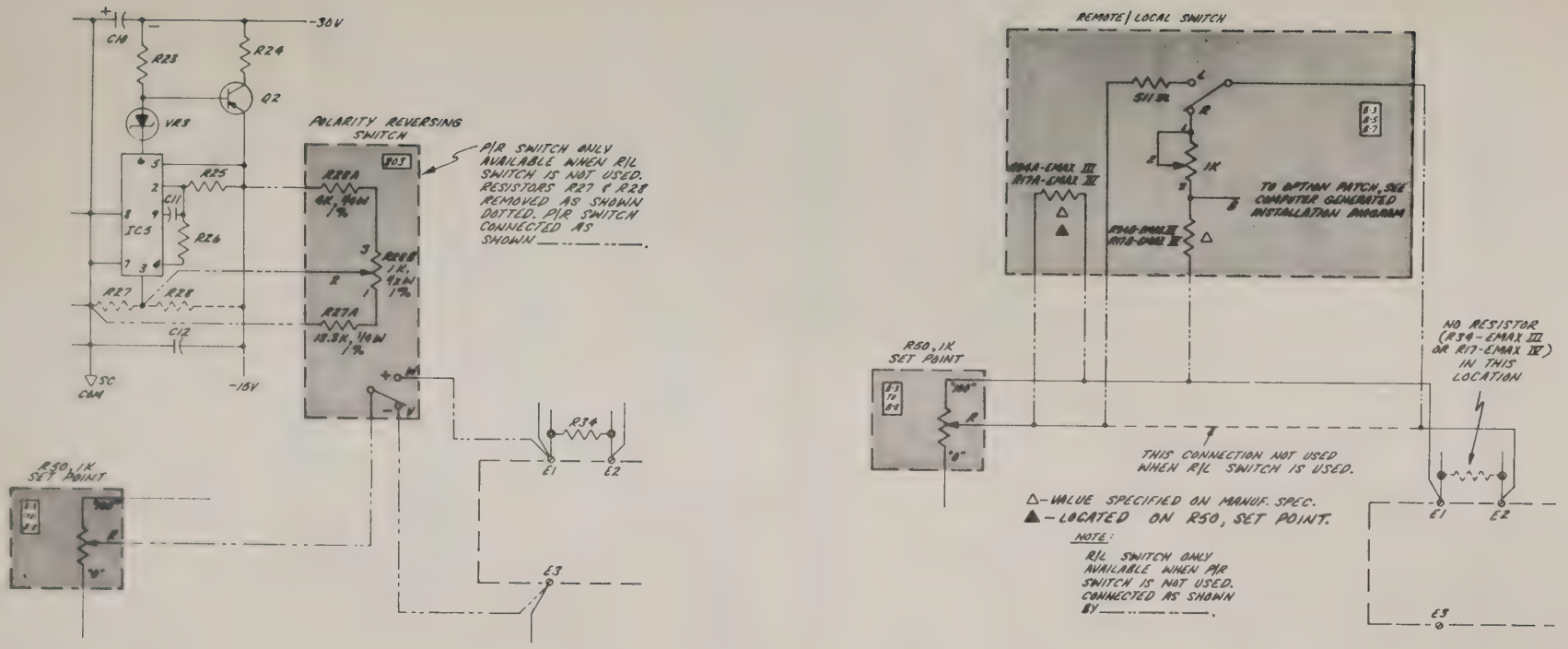
444969 P.A.T. MANUAL STATION

SYMBOL	DESCRIPTION	PART NO.
R1	RESISTOR 1.33K, ¼W, 1%	411377
R2	RESISTOR 1K, ¼W, 1%	411300
,R6,R7	RESISTOR 10K, ¼W, 1%	311785
R5,R8	RESISTOR 20K, ¼W, 1%	311780
*R3		
R4	RESISTOR 220Ω, ¼W, 10%	311113

* MUST BE ORDERED SEPARATELY FROM STATION.

E6360

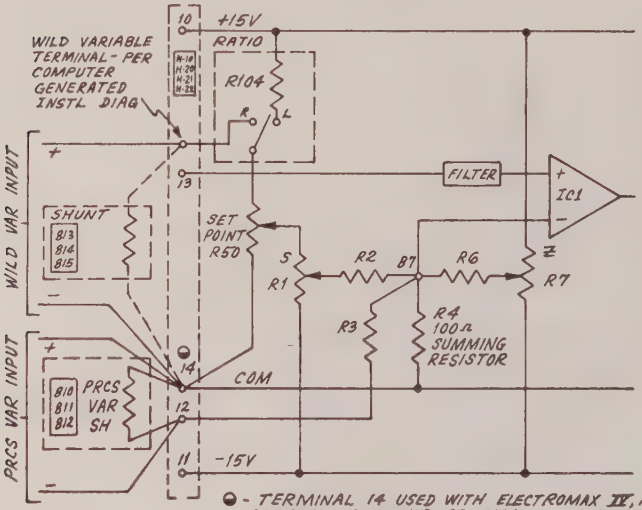
Fig. A5(b)–P.A.T. manual station card assembly 444969 (G5).



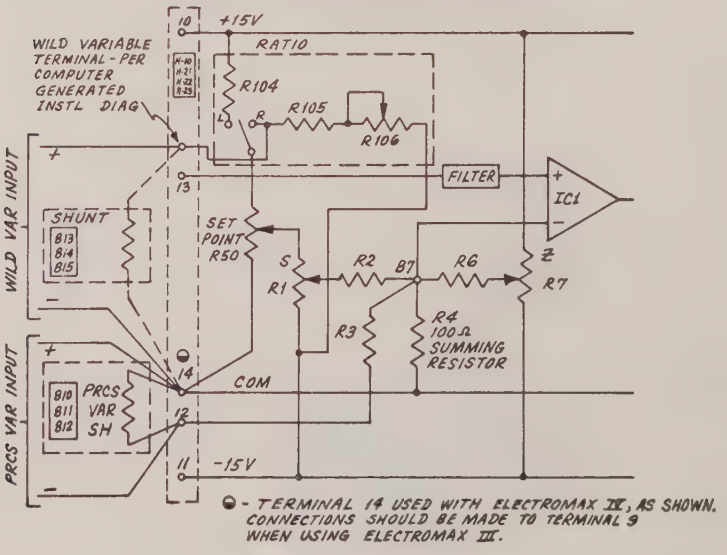
E7138

Fig. A5(c)–Polarity switch circuit and remote/local switch circuit.

RATIO CIRCUIT WITH 860 OPTION – ZERO BASED INPUT
(0-4V WILD VARIABLE) – ELECTROMAX III & IV.

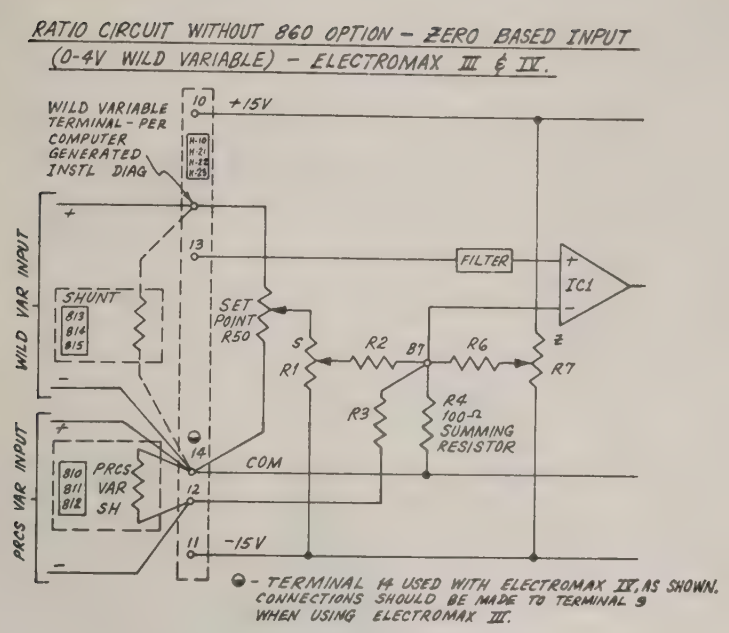


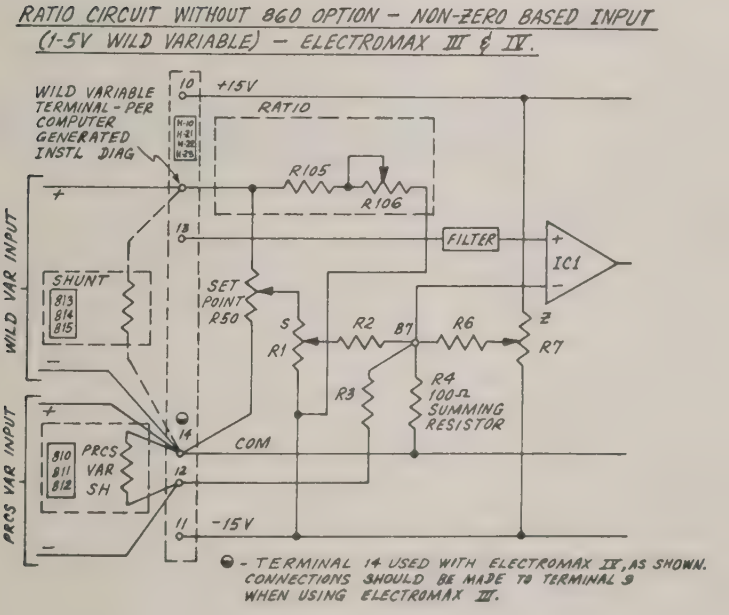
RATIO CIRCUIT WITH 860 OPTION – NON-ZERO BASED INPUT
(1-5V WILD VARIABLE) – ELECTROMAX III & IV.



E7139

Fig. A6(a)–Ratio circuits with option 860.





E7140

Fig. A6(b)–Ratio circuits without option 860.

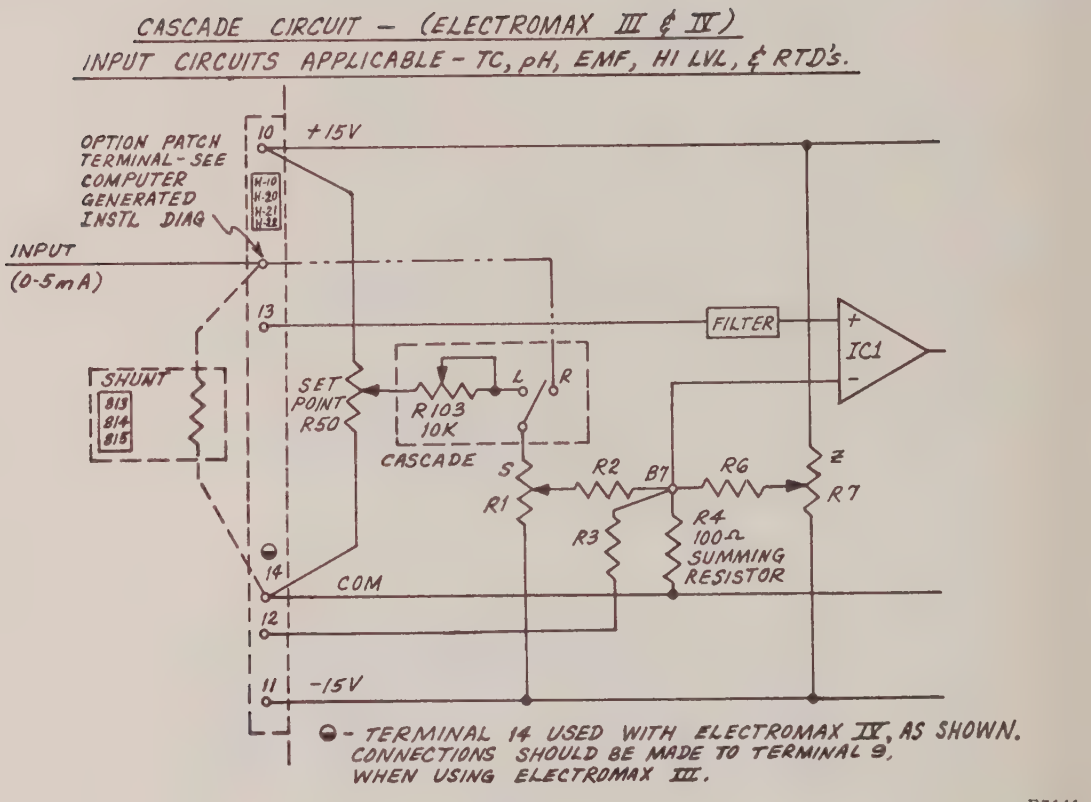
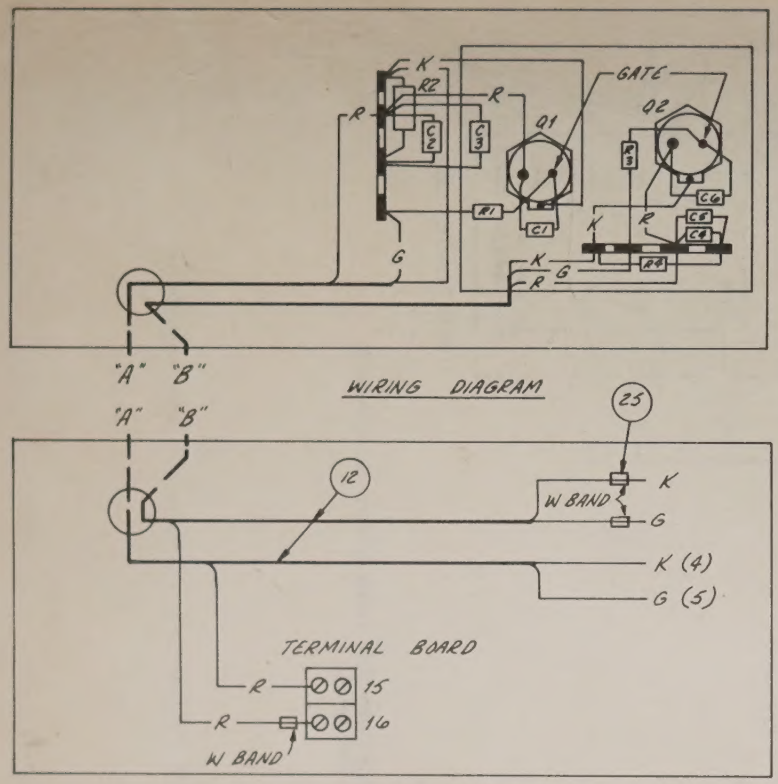
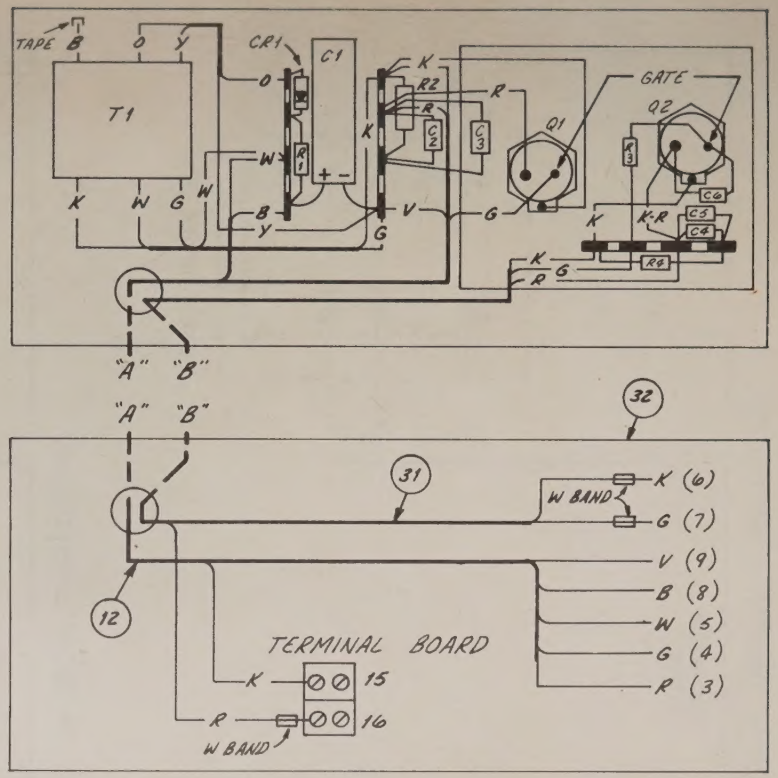


Fig. A6(c)–Cascade circuit (option 850).



173121 – ON-OFF TRIAC – DUAL CONTROL



173120 – P.E.T. TRIAC – DUAL CONTROL

SYMBOL	DESCRIPTION	PART NO.
C1 C6	CAPACITOR 0.02UF, 450V	023096
C2,C3 C4,C5	CAPACITOR 0.05UF, 500V	023433
R1,R3	RESISTOR 1K, ½W, 10%	011144
R2,R4	RESISTOR 100Ω, ½W, 10F	011132
△ Q1,Q2	TRIAC	057248
	HEAT SINK	190090

SYMBOL	DESCRIPTION	PART NO.
△ C1	CAPACITOR 100UF, 40V	023690
C2,C3 C4,C5	CAPACITOR 0.05UF, 500V	023433
C6	CAPACITOR 0.02UF, 450V	023096
R1	RESISTOR 10K, 1/4W, 10%	011773
R2,R4	RESISTOR 100Ω, ½W, 10%	011132
R3	RESISTOR 1K, ½W, 10%	011144
△ Q1,Q2	TRIAC	057248
△ CR1	DIODE	057134
△ T1	TRANSFORMER	019424
	HEAT SINK	190090

CE7142

Fig. A7–ON-OFF and P.E.T. triac dual control assemblies (173120 & 173121).

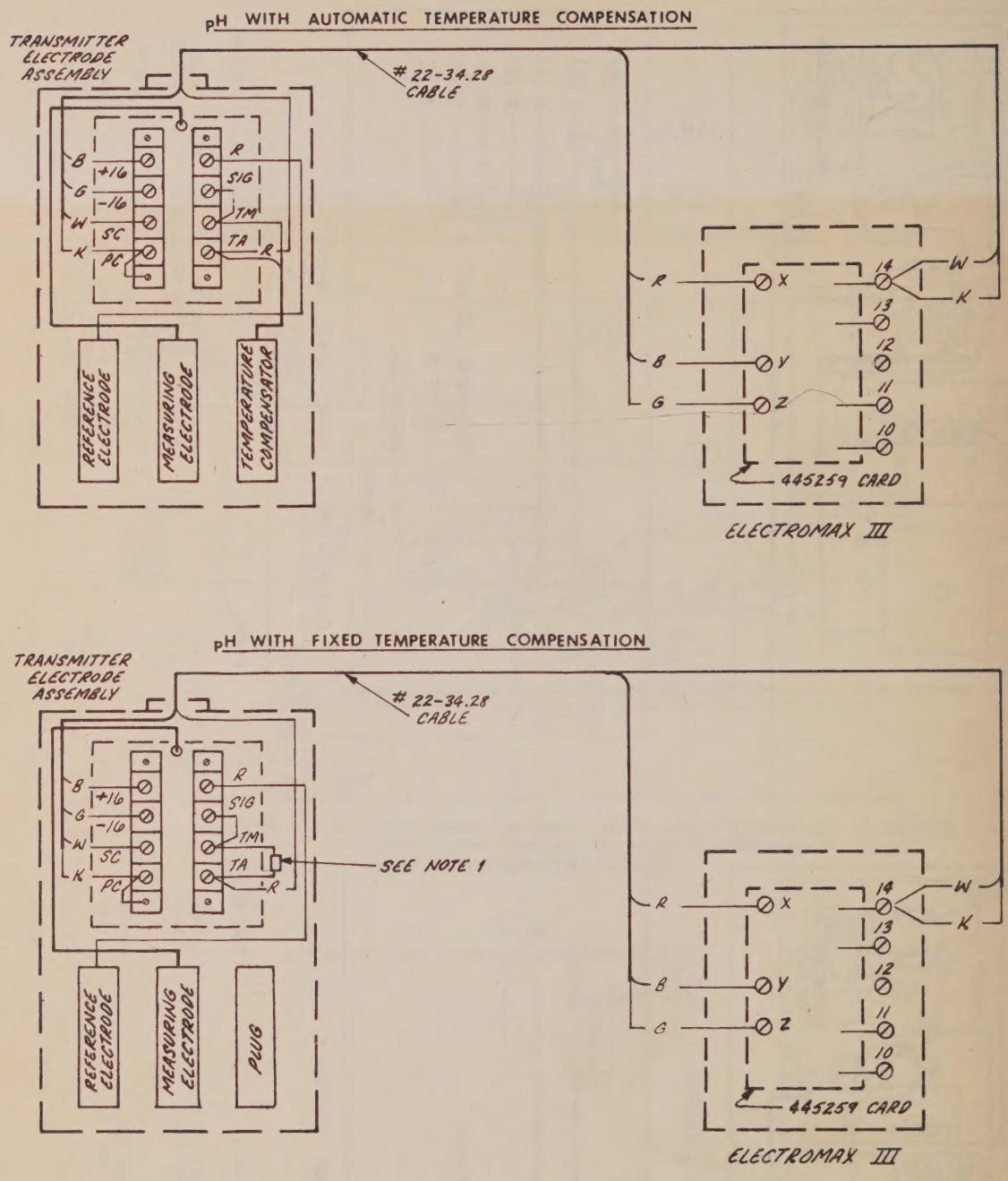


Fig. A8–7773/7779 Transmitter to Electromax III interconnections.

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